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L12: Entry 1 of 42 File: USPT Jan 7, 2003

DOCUMENT-IDENTIFIER: US 6505139 B1
TITLE: Speed ratio control device for vehicle

Abstract Text (1):
The vehicle comprises a continuously variable transmission and traction control system (TCS) which controls a driving force. When the TCS is not operating, a controller computes a final target ratio based on a sensor detected vehicle speed. When the TCS is operating, the final target ratio is computed based on an estimated vehicle speed, and the final target ratio is limited by a speed ratio upper limiting value computed based on the sensor detected vehicle speed. The controller controls a speed change actuator so that a real speed ratio approaches the final target ratio.

Brief Summary Text (2):
The present invention relates to speed change control for a vehicle with a continuously variable transmission (CVT), and especially to speed change control during operation of a traction control system.

Brief Summary Text (4):
When a traction control system (TCS) which suppresses tire slip by decreasing the driving force operates, a driving force changes, and a driving wheel speed fluctuates. Therefore, when a final target ratio is computed based on the driving wheel speed during traction control and speed ratio control is performed so that a real speed ratio approaches the final target ratio, the real speed ratio will fluctuate.

Brief Summary Text (8):
When an up-shift becomes hard to perform, the engine rotation speed increases Moreover, if the driving wheels slip and the driving wheel speed increases, the rotation speed of the engine may increase too much.

Brief Summary Text (9):
It is therefore an object of this invention to prevent the engine rotation speed increasing excessively while suppressing speed ratio fluctuation during operation of a traction control system.

Brief Summary Text (10):
In order to achieve above object this invention provides a speed ratio control device for a vehicle comprising a continuously variable transmission and traction control system which controls a driving force. The device comprises a sensor which detects a vehicle speed, an actuator which changes the speed ratio of the transmission, and a microprocessor programmed to estimate a vehicle speed based on a running state, compute the target ratio of the transmission based on the sensor detected speed when the traction control system is not operating, compute the target ratio of the transmission based on the estimated vehicle speed, and limit the computed target ratio to a speed ratio upper limiting value computed based on the sensor detected vehicle speed, when the traction control system is operating, and control the actuator so that the speed ratio of the transmission approaches the target ratio.

Drawing Description Text (10):
FIG. 9 is a time chart showing how a sensor detected vehicle speed (=driving wheel speed) and an estimated vehicle speed (=driven wheel speed) vary during operation of a traction control system.

Detailed Description Text (25):
The controller 61 comprises a microprocessor, read only memory, random access memory and input/output interface, and the following signals are input to the controller 61 as shown in FIG. 2. driven wheel speed signal from a driven wheel speed sensor 58 acceleration signal from an acceleration sensor 59 throttle opening signal TVO from a throttle opening sensor 62 sensor detected vehicle speed signal VSPSEN from a vehicle speed sensor 63 transmission input rotation speed signal Ni (or engine rotation speed signal Ne) from an input rotation sensor 64 transmission output rotation speed signal No from an output rotation sensor 65 transmission oil temperature signal TMP from an oil temperature sensor 66 line pressure signal PL from a line pressure sensor 67 engine rotation speed signal Ne from an engine rotation speed sensor 68 shift lever position signal from an inhibitor switch 60 up-shift signal and down-shift signal from a manual shift switch 69 selected mode signal from a mode selection switch 70 torque-down signal from an engine controller 310 signal showing an operating state of an anti-lock brake system (ABS) 320 from the anti-lock brake system 320 signal showing an operating state of a traction control system (TCS) 330 from the traction control system 330. auto-cruise signal from a cruise control system 340

Detailed Description Text (33):
A time constant calculating element 74 determines a first speed change time constant Tg1 and second speed change time constant Tg2 used in speed change control according to the shift lever position (the normal running position "D" or sports running position "Ds", etc.), vehicle speed VSP, throttle opening TVO, engine rotation speed Ne, accelerator pedal depression rate, the torque-down signal, the anti-lock brake control signal, the traction control signal, the auto-cruise signal, and a speed ratio difference RtoERR between the real speed ratio Ratio and a transient target ratio Ratio0 described later, and computes a difference Eip between the final target ratio i* and transient target ratio Ratio0.

Detailed Description Text (84):
Thus, when the ABS 320 or the TCS 330 are operating, as the estimated vehicle speed VSPFL is set as the vehicle speed VSP used for speed ratio control, the fluctuation due to speed ratio fluctuation of the sensor detected vehicle speed VSPSEN is stopped. Moreover, the speed ratio can be prevented from varying on the large side and encouraging slip.

Detailed Description Text (96):
Further, as the up-shift which is not subject to limitation by the speed ratio upper limiting value iLOWLIM can be performed when the driving wheels slip and the driving wheel speed increases, increase of the engine rotation speed Ne can be suppressed.

CLAIMS:

1. A speed ratio control device for a vehicle comprising a continuously variable transmission and traction control system which controls a driving force, the device comprising: a sensor which detects a vehicle speed, an actuator which changes the speed ratio of the transmission, and a microprocessor programmed to: estimate a vehicle speed based on a running state, compute the target ratio of the transmission based on the sensor detected speed when the traction control system is not operating, compute the target ratio of the transmission based on the estimated vehicle speed, and limit the computed target ratio to a speed ratio upper limiting value computed based on the sensor detected vehicle speed, when the traction control system is operating, and control the actuator so that the speed ratio of the transmission approaches the target ratio.

5. A speed ratio control device for a vehicle comprising a continuously variable transmission and traction control system which controls a driving force, the device comprising: means for detecting a vehicle speed, an actuator which changes the speed ratio of the transmission, means for estimating a vehicle speed based on a running state, means for computing the target ratio of the transmission based on the sensor detected speed when the traction control system is not operating, means for computing the target ratio of the transmission based on the estimated vehicle speed, and limiting the computed target ratio to a speed ratio upper limiting value computed based on the sensor detected vehicle speed, when the traction control system is operating, and means for controlling the actuator so that the speed ratio of the

transmission approaches the target ratio.

6. A method for controlling the speed ratio of a continuously variable transmission in a vehicle comprising the transmission and a traction control system, the method comprising: detecting a vehicle speed; estimating a vehicle speed based on a running state; computing a target ratio of the transmission based on the detected vehicle speed when the traction control system is not operating; computing the target ratio of the transmission based on the estimated vehicle speed, and limiting the computed target ratio to a speed ratio upper limiting value computed based on the estimated vehicle speed, when the traction control system is operating; and controlling the speed ratio of the transmission to approach the target speed ratio.

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L12: Entry 3 of 42 File: USPT May 7, 2002

DOCUMENT-IDENTIFIER: US 6385526 B1
TITLE: Vehicle traction control with power shift modification

Abstract Text (1):
A vehicle traction control increases the allowed wheel spin for a driven wheel when (1) sensed vehicle speed is within a predetermined speed range corresponding to near maximum engine speed for the sensed currently used gear of the transmission, (2) sensed vehicle turn curvature is within a predetermined curvature range of zero curvature, (3) sensed vehicle longitudinal acceleration has not been below a predetermined high acceleration for a predetermined time, and (4) sensed vehicle engine speed has not been below a predetermined high engine speed for the predetermined time. The tests are calibrated to provide the increase in a very narrow range of conditions corresponding to high performance operation, and particularly power shifts of a manual shift transmission, on a racetrack with a high coefficient surface.

Brief Summary Text (2):
The technical field of this invention is motor vehicle traction control, and particularly to its use in vehicles on racetracks.

Brief Summary Text (4):
Vehicle traction controls are used to sense driven wheel slip under powered (non-braking) conditions and control one or both of the vehicle brakes or engine to spin down the driven wheels as necessary to regain traction. But a vehicle involved in high performance operation on a racetrack may lose traction when in a high acceleration state or during gear shift when the new gear is engaged. The wheel spin-up activates the traction control system, which causes a reduction in engine power or a brake activation of the spun-up wheel that reduces vehicle performance at a time when it is most demanded. It is undesirable to merely retune the traction control system to ignore the spin-up, because the action of the traction control system is desirable to handle identical spin-ups encountered in non-controlled maneuvers, particularly in vehicles that may also be operated in normal, off-track driving.

Brief Summary Text (6):
The apparatus of this invention provides traction control for a vehicle by sensing vehicle speed, the rotational speed of a driven wheel, vehicle longitudinal acceleration; vehicle engine speed, vehicle turn curvature, and a currently used gear of the transmission and increasing the predetermined target delta speed value of the traction control when all of the following are true:

Drawing Description Text (2):
FIG. 1 shows a schematic block diagram of a vehicle with a traction control system according to this invention.

Drawing Description Text (3):
FIGS. 2A and 2B show a flow chart illustrating the operation of the traction control system used in the vehicle of FIG. 1.

Detailed Description Text (2):
Referring to FIG. 1, a motor vehicle 10 has a powertrain 12 including an engine and transmission for driving a pair of driven wheels 20. Vehicle 10 also has a pair of non-driven wheels 22. One of the sets of driven wheels 20 and non-driven wheels 22 is

provided with steering apparatus 24 including a steering control and may include a steering sensor for providing a steer angle signal. A brake system 26 provides a brake control and brake modules at each of the driven wheels 20 and non-driven wheels 22 including a wheel speed sensor, and further provides an indication of the transmission gear in use as calculated from a ratio of engine speed to driven wheel speed. Powertrain 12 is provided with an engine speed sensor.

Detailed Description Text (3):
A traction controller 40 is shown as a separate control but would most likely be included within the control portions of brake system 26, depending on available computer power, ease of input/output connections and other relevant factors known in the art. Regardless of location and packaging, traction controller 40 receives as inputs steering sensor signals from steering apparatus 24, wheel speed sensors sensor signals from brake system 26 and engine speed signals from powertrain 12. An accelerometer 36 may be provided to output a longitudinal acceleration signal. Alternatively, accelerometer 36 and the steering sensor in steering apparatus 24 may be eliminated if traction controller 40 derives a vehicle longitudinal acceleration and a vehicle turn curvature from non-driven wheel speed signals from brake system 26. The outputs of traction controller 40 may be to either or both of powertrain 12 and brake system 26, to provide control through reduction in engine power or application of vehicle brakes, as known in the art.

Detailed Description Text (4):
FIG. 2A and 2B show a flow chart illustrating the operation of traction controller 40. Referring to FIG. 2A, program POWER SHIFT begins at step 60 by reading or deriving the vehicle dynamic parameters to be used in the following steps. A vehicle speed value VSPD is derived from the wheel speed signals from sensors on the non-driven wheels. One of the signals, or a combination of the two, may be used as known in the art. A vehicle longitudinal acceleration signal VACCEL may be received from accelerometer 36; but that sensor may be eliminated if VACCEL is derived as the derivative of vehicle speed signal VSPD. An engine speed signal ENGSPD is obtained from powertrain controller 16; and a vehicle turn curvature signal is derived from steering sensor 26 or from a difference in the wheel speed signals of the non-driven wheels, as known in the art.

Detailed Description Text (5):
Having derived the necessary values, the program continues by comparing vehicle acceleration VACCEL at step 62 with a calibrated reference value ACCREF. The calibrated reference ACCREF is sufficiently high that it is not attainable except on a high coefficient (friction) road surface, so that the program will not override normal traction control on wet or other slipper surfaces. If VACCEL is greater, engine speed ENGSPD is compared at step 64 with a calibrated reference value ESPDREF. The calibrated reference ESPDREF is set somewhere near maximum allowable speed, or "red line" speed, for the engine: for example, about 500 RPM lower. If ENGSPD is greater, a timer value TIMER is set to a value START at step 66. If either of steps 62 and 64 results in a lesser value, the program alternatively decrements TIMER at step 68. Since the reference values ACCREF and ESPDREF are very high in the ranges for acceleration and engine speed, respectively, they are rarely found, especially simultaneously, except under racing conditions at a high speed track in dry weather.

Detailed Description Text (6):
From either of steps 66 and 68, the program proceeds to test TIMER at step 70. If the timer has timed out, the program proceeds to 82 and either calls for or fails to override the normal target delta velocity of the wheel in traction control: thus traction control operates to bring the wheel speed of the spun up wheel down to its desired speed to regain its traction. But, due to the action of step 66, which repeatedly restarts the timer at the full value START on every loop in which engine speed ESPD and vehicle longitudinal acceleration VACCEL both exceed their references, the remainder of the program will be activated as long as those conditions prevail and for a time thereafter determined by the value of START and the loop rate of the program. The values are set so that, as a gear shift occurs, the action of the remainder of the program, to be described below, will not end immediately as the acceleration or engine speed drops during the shift. Thus, the value of START is set to provide a timer duration related to the expected length of a shift in gear.

Detailed Description Text (7):
From step 70 the program determines if vehicle speed VSPD is in a range above the normal driving speed for the transmission gear in use, and preferably near the maximum or "red line" speed for the gear. The range is set by two calibrated references: VSPDHI, which is set at a vehicle speed corresponding to about maximum or "red line" engine speed for the gear, and VSPDLO, which is set to a vehicle speed corresponding to a calibrated speed somewhat lower. Step 72 determines if vehicle speed VSPD is greater than the low reference VSPDLO; and step 74 determines if VSPD is less than the upper reference VSPDHI. Together, steps 72 and 74 determine if the vehicle speed is within the predetermined range. During the shift, while the acceleration and/or engine speed temporarily drop with the removal of power from the driving wheels, the vehicle speed does not ordinarily fall. Therefore, an engine speed straying out of this range is a signal that the traction control should probably not be overridden. In addition, it should be noted that the vehicle speed references VSPDLO and VSPDHI will be different for each gear of powertrain 12. Typically, the overriding of traction control will only be allowed in shifts from lower gears--for example, from 1.sup.st or 2.sup.nd gear in a manual 4 speed transmission. Values are stored for each of those shifts and are chosen during program operation on the basis of the sense transmission. For higher gears, the calibrated values may be reversed in size to prevent traction control overriding action of the program.

Detailed Description Text (8):
If steps 72 and 74 determine that vehicle speed is in the proper range, step 76 determines if the vehicle is being steered for straight driving. If not, overriding traction control is probably not a good idea. Thus, step 76 compares the turn curvature of the vehicle TRNCRV with a reference value CRVREF, that defines a very narrow angle range around straight ahead. Typically, the turn curvature is expressed in degrees of steering angle, with zero nominally defined as straight. Thus, the reference value stored would be positive, and the value compared would be an absolute value, since the direction of any turn doesn't really matter.

Detailed Description Text (10):
If each of the tests of steps 70-78 produces a yes answer, the program substitutes a calibrated TARGET DELTA VELOCITY that is significantly higher than the normal value of the traction control system for the driven wheel that is in traction control. With a higher TARGET DELTA VELOCITY, the traction control will allow a higher wheel spin, and thus potentially greater power transfer at the tire/track interface. The value is calibratable to provide a desired combination of power transfer and traction.

CLAIMS:

1. A traction control for a vehicle with an engine and a transmission driving a driven wheel comprising:

means for sensing vehicle speed;

means for sensing the rotational speed of the driven wheel;

means for providing speed reduction of the driven vehicle wheel when the sensed rotational speed thereof exceeds a first predetermined target delta speed value above the sensed vehicle speed;

means for sensing vehicle longitudinal acceleration;

means for sensing vehicle engine speed;

means for sensing vehicle turn curvature;

means for sensing a currently used gear of the transmission;

means for substituting a second predetermined target delta speed value, greater than the first target delta speed value, for the first predetermined target delta speed value when all of the following are true:

(1) the sensed vehicle speed is within a predetermined speed range corresponding to

near maximum engine speed for the sensed currently used gear of the transmission;

(2) the sensed vehicle turn curvature is within a predetermined curvature range of zero curvature;

(3) the sensed vehicle longitudinal acceleration has not been below a predetermined high acceleration for a first predetermined time; and

(4) the sensed vehicle engine speed has not been below a predetermined high engine speed for a second predetermined time.

L12: Entry 25 of 42 File: USPT Nov 3, 1992

DOCUMENT-IDENTIFIER: US 5159990 A
**** See image for Certificate of Correction ****
TITLE: Wheel slippage control apparatus in motor vehicle

Abstract Text (1):
A slip control apparatus for use in a motor vehicle having an engine for generating a motive power to drive the motor vehicle. The apparatus comprises a first detector for detecting a speed of a driven wheel of the motor vehicle which is driven by the motive power generated from the engine, a second detector for detecting a running speed of the motor vehicle and a third detector for detecting an acceleration of the driven wheel. Also included in the apparatus are a decision unit for determining the occurrence of slipping of the driven wheel on the basis of the detection results of the first and second detectors, a driving force adjusting device for adjusting a driving force of the motor vehicle, and a control unit for controlling the slip of the driven wheel on the basis of information from the first to third detectors. The control unit controls the driving force adjusting device on the basis of the acceleration detected by the third detector when the decision device has determined the occurrence of slipping of the driven wheel.

Brief Summary Text (3):
Various types of slippage control apparatus have been known, one approach being disclosed in Japanese Patent provisional Publication No. 62-121839 in which the opening degree of a throttle valve is controlled so as to keep the slip ratio S in a predetermined range, the slip ratio being determined on the basis of a vehicle speed Vb and a driven-wheel speed Vd in accordance with an equation S=(Vd -Vb)/Vd. Another known technique involves cutting off supply of fuel into an internal combustion engine in response to occurrence of a slippage of a driven wheel of the vehicle or controlling the output torque of an engine by retarding the ignition timing of the engine.

Brief Summary Text (7):
It is therefore an object of the present invention to provide a slip control apparatus for use in a motor vehicle which is capable of attaining to both stable running and excellent acceleration performance.

Brief Summary Text (8):
A slip control apparatus according to the present invention controls slipping by adjustment of a driving force of a motor vehicle having an engine for generating a motive power to drive the motor vehicle. That is, the apparatus comprises a control unit for controlling the slip of a driven wheel in accordance with signals from a first detector for detecting a speed of the driven wheel of the motor vehicle which is driven by the motive power generated from the engine, a second detector for detecting a running speed of the motor vehicle and a third detector for detecting an acceleration of the driven wheel. The control unit controls a driving force adjusting device for adjusting a driving force of the motor vehicle on the basis of the acceleration detected by the third detector when slipping of the driven wheel occurs. The decision of the occurrence of slipping is made on the basis of the detection results of the first and second detectors.

Detailed Description Text (2):
Referring now to FIG. 1, there is schematically illustrated a slip control apparatus according to an embodiment of the present invention which is incorporated into a motor

vehicle including a spark-ignition type four-cylinder gasoline-use internal combustion engine 1. The engine 1 is coupled to an air intake pipe 2 and an exhaust pipe 50, the intake pipe 2 comprising an assembly portion 2a connected to an air cleaner (not shown), a surge tank 2b connected to the assembly portion 2a and branch portions 2c provided at the surge tank 2b in correspondance with the respective cylinders of the engine 1. In the assembly portion 2a is provided a throttle valve 3 for controlling the engine output by adjusting the intake air amount into the engine 1. A valve shaft of the throttle valve 3 is coupled to a stepping motor 4 for controlling the opening degree of the throttle valve 3 and further a throttle sensor 5 for sensing the opening degree of the throttle valve 3. Here, on the stepping motor 4 is disposed a full-close sensor 4a for detecting the full-closing position of the motor 4. Further, at an upstream position of the throttle valve 3 of the assembly portion 2a is provided an intake air temperature sensor 6. In the surge tank 2b is provided an intake pipe pressure sensor 7 for detecting the pressure in the intake pipe 2, and to the branch portions 2c are attached solenoid-operated fuel injection valves 8. In addition, the engine 1 is equipped with ignition plugs 9 for igniting an air-fuel mixture to be introduced into the respective cylinders. The ignition plug 9 is coupled through a high-voltage cord to a distributor 10 which is in turn connected electrically to an igniter 11 and on which provided is a rotation sensor 10a for outputting a signal synchronous with the rotation of the engine 1. Still further, the engine is provided with a water temperature sensor 12 for detecting the temperature of cooling water for the engine 1.

Detailed Description Text (6):
A signal input base process of the step 4000 will be described hereinbelow with reference to a flow chart of FIG. 3. In a step 4100, inputted are the analog signals indicative of an intake air temperature THA, an acceleration-pedal operating amount AA, an intake pipe pressure PM, a cooling water temperature THW, a throttle opening degree TA and a gear position GP, and in a subsequent step 4200 are inputted the digital signals including an acceleration-pedal full-closing signal IDL, a motor full-closing position signal MOFF and a braking-pedal depression signal BRK. A step 4300 follows to perform a vehicle speed signal process, where, for example, a reference speed necessary for control is calculated on the basis of a front-right wheel speed VFR, a front-left wheel speed VFL, a rear-right wheel speed VRR and a rear-left wheel speed VRL obtained by a vehicle-speed interrupt process synchronous with the wheel speed as illustrated in FIG. 4. In detail, as shown in FIG. 5, a step 4310 is executed to obtain, as a vehicle speed, the average speed of the non-driven wheels, i.e., the front-right wheel VFR and the front-left wheel VFL, followed by a step 4320 to compare the vehicle speed V with a first decision speed KS. If V.gtoreq.KS, control goes to a step 4330, and if V<KS, control goes to a step 4340. In the step 4330, a target driven wheel speed Vt is obtained as Vt=V.times.a target slip ratio S, and in the step 4340, it is obtained as Vt=V+a first offset speed Soff. Here, the first decision speed KS is determined so that Soff=KS.times.S. That is, as shown in FIG. 6, the drive wheel speed is controlled so as to be greater by at least the first offset speed Soff than the vehicle speed V.

Detailed Description Text (7):
After the determination of the target driven wheel speed Vt, a step 4350 is executed to compare the vehicle speed V with a second decision speed KT. If V.gtoreq.KT, control goes to a step 4370, and if not, control goes to a step 4360. In the step 4370, a traction control start speed Vh is determined as Vh=V.times.a traction control start slip ratio H, and in the step 4360, it is determined as Vh=V +an offset speed Hoff. Here, the second decision speed KT is set so that Hoff=KT.times.H.

Detailed Description Text (8):
Thus, as shown in FIG. 6, when the driven wheel speed becomes greater by at least the second offset speed Hoff than the vehicle speed V, the occurrence of slippage is determined with respect to the drive wheel and the traction control start speed Vh is set so that the traction control which controls the slippage is started. Here, it may be preferable that S=0.1, Soff=2 km/h, KS=20 km/h, H=0.2, Hoff=4 km/h, KT=20 km/h.

Detailed Description Text (10):
Returning again to FIG. 3, in a step 4400 is executed a slip state decision process illustrated in FIG. 7. In a step 4410, the speed VRLF of the rear-left wheel (driven wheel) 17 is compared with the traction target speed Vt. If VRLF<Vt, control proceeds

to a step 4420 where a rear-left wheel reservation speed XVRL is compared with the rear-left wheel speed VRLF. If the result of the comparison in the step 4420 is that XVRL is equal to VRLF, control goes to a step 4450 so as to increment the value of the counter CRL by one. On the other hand, if the result of the comparison in the step 4420 is that XVRL is not equal to VRLF, control goes to a step 4430 to set the rear-left wheel speed VRLF instead of the rear-left wheel reservation speed XVRL, followed by a step 4440 in which the value of the counter CRL is set to be "1". Thereafter, a step 4460 follows to clear the left driven wheel initial acceleration GRL, followed by a step 4520 for a right driven wheel process.

Detailed Description Text (11):
On the other hand, if the decision in the step 4410 is VRLF.gtoreq.Vt, control goes to a step 4470 so as to compare VRLF with the traction start decision speed Vh. If VRLF<Vh, a step 4480 follows to increment the value of the counter CRL by one, followed by the step 4520. If VRLF.gtoreq.Vh in the step 4470, control goes to a step 4490 in order to set the value of the rear-left wheel speed VRLF instead of a left driven wheel final speed YVRL, then followed by a step 4500 to obtain a left driven wheel initial acceleration GRL on the basis of XVRL, YVRL and CRL. Thereafter, in a step 4510, a traction speed condition flag FTS is set to be "1", and the step 4510 is followed by the step 4520. Thus, the occurrence of slippage of the rear-left wheel 17 is decided with the processes of the steps 4410 to 4510 and further the acceleration GRL of the rear-left wheel 17 (left driven wheel initial acceleration) at the time of the decision can be obtained.

Detailed Description Text (13):
Here, if obtaining the initial acceleration GRL (GRR) when the decision is made as the occurrence of slippage, generally, a process is performed to obtain the difference between the driven wheel speed VRLF (VRRF) at the time of the slippage decision and the drive wheel speed VRLF (VRRF) immediately before the slippage decision. However, when the motor vehicle is running on an irregular road surface and particularly the vehicle speed is low and the slip ratio is small, the driven wheel speed is difficult to be stable and as shown in FIG. 6 the speed does not vary during a time corresponding to several sampling intervals and thereafter the speed can be varied rapidly. Since the initial acceleration value, as described above, is indicative of the magnitude of the frictional coefficient between the running road surface and the wheel tire, in order to accurately obtain the the initial acceleration value, it is required to not only take into account the range from a point A' of the driven wheel speed VRLF to a point B but also the range (from a point A to the point A') in which the speed does not vary. That is, it is required to use the inclination between the point A and the point B. The reason that the driven wheel speed VRLF does not increase between the point A and the point A' irrespective of application of a constant torque is that the torque is once absorbed by the drive system due to deflection of the tire and the drive shaft and then discharged at a stretch in the range from the point A' to the point B.

Detailed Description Text (14):
Further, the reason that, for the calculation of the initial acceleration GFI in the above process, the driven wheel wheel VRLF (which is smaller than the target driven wheel speed Vt) is used as the initial point of the calculation is to obtain the friction state in the vicinity of the target driven wheel speed Vt during the traction control. This is required to accurately obtain the initial acceleration GFI.

Detailed Description Text (15):
In the signal input base process step 4000, the slippage state decision step 4400 is followed by a step 4600 in order to decide the start or termination of the traction control as illustrated in detail in FIG. 8. In FIG. 8, in a step 4610 which failure flag FF which is set when the drive system and others of the throttle valve 3 is in the abnormal state whereby, the decision in terms of whether the throttle valve 3 enters into the abnormal state is made in different process. If the flag FF is set, control goes to a step 4660 to reset a traction executing flag Ft, then terminated. If the flag FF is not in the set state, control goes to a step 4615 in order to check whether the signal BRK of the brake sensor 21a is ON. If ON, control similarly proceeds to the step 4660. If OFF, control advances to a step 4620. In the step 4620, the acceleration-pedal operating amount AA is compared with the operating amount decision value KA (in this embodiment, KA=1.5 degrees). If AA.1toreq.KA, control goes

to the step 4660. On the other hand, If AA>KA, control goes to a step 4630. In the step 4630, it is checked whether the motor vehicle is on the traction control in accordance with the traction executing flag FT. If so, control goes to a step 4670 to compare a target opening degree THTRC on the traction with a target throttle opening degree TH calculated in the throttle control base process step 6000. When TH.ltoreq.THTRC, control goes to a step 4680 to reset the traction executing flag FT, then followed by a step 4690. On the other hand, if TH>THTRC, control directly goes to the step 4690 so as to reset a traction speed condition flag FTS, thereby causing termination of this process. When in the step 4630 the traction executing flag FT is reset, that is, when the traction is not executed, a step 4640 follows to check whether the traction speed condition flag FTS is set. If so, control goes to a step 4650 to set the traction executing flag FT. If not, this operation is terminated without entering into the step 4650.

Detailed Description Text (16):
With the above-described signal input base process step 4000, data necessary for the traction control are prepared and control using the data is performed in accordance with a program illustrated in FIG. 2.

Detailed Description Text (17):
FIG. 9 shows a fuel injection base process step 5000. In a step 5100, a basic pulse width is determined on the basis of the intake pipe pressure PM and the engine speed Ne and further corrected in accordance with the engine cooling water temperature THW and the intake air temperature THA so as to obtain a fuel injection pulse width TI. A step 5210 follows to check the traction executing flag FT. If it is reset, this operation is terminated. On the other hand, the traction executing flag is in the set state, a step 5220 follows to check whether the traction executing flag FT is set immediately before. If so, control goes to a step 5230 to set a fuel cut time period KCFC in accordance with the initial acceleration GFI of the driven wheel obtained in the slip state decision step 4400 using a predetermined map prestored in the ROM 30d. The cut time period KCFC becomes longer as the initial acceleration GFI is greater, that is, as the frictional coefficient .mu. is low and hence the friction reaction force from the road surface is smaller. The contents of the map are determined as shown in FIG. 10, for example. Subsequently, a step 5240 is executed to set the cut time period KCFC to a fuel cut counter CFC, followed by a step 5270.

Detailed Description Text (18):
On the other hand, if the answer of the step 5220 is "NO", that is, if the traction control is being performed so as to repress the slippage developed, control goes to a step 5250 to check the value of the fuel cut counter CFC. If CFC =0, control goes to a step 5280. If not, control goes to a step 5260 to decrement the fuel cut counter CFC by one, then followed by a step 5270 to set the fuel injection pulse width TI, determined in the step 5100, to 0. Thereafter, control advances to a step 5280 in which the ignition timing SA is determined on the basis of various input signals.

Detailed Description Text (19):
The calculation of the engine speed Ne used in the above-described operation and the opening process of the injection valve 8 follows the fuel injection pulse width TI determined in the above-mentioned operation are performed by the rotation interrupt (occurrence at every crank angle 30.degree.) as illustrated in FIG. 11. Through the steps 5210 to 5250, the fuel injection is stopped for a predetermined time period after the time that the decision is made where the slippage of the driven wheel occurs, the predetermined time period being determined on the basis of the initial acceleration GFI. This is for covering the fact that quick reduction of the engine torque is difficult to be achieved by only the torque reduction due to the throttle valve 3 (which will be described hereinafter) because of response time lag of the intake system immediately after the start of the traction control.

Detailed Description Text (20):
A throttle control base process step 6000 will be described hereinbelow with reference to FIG. 12. In FIG. 12, a step 6010 is first executed so as to obtain the maximum throttle opening degree THMAX corresponding to the engine speed Ne by the interpolation calculation of a data table, as illustrated in FIG. 13, which is stored in the ROM 30d. This is for ensuring the response of the throttle valve 3 at the time of valve-closing by obtaining the saturation point of the engine torque with respect

to the throttle opening degree and inhibiting more opening of the throttle valve 3. In a subsequent step 6020, a smaller one of the maximum throttle opening degree THMAX and an acceleration-pedal correspondance target throttle opening degree THAA is set to the target throttle opening degree TH. A step 6030 follows to check the traction executing flag FT. If the traction executing flag is set, control goes to a step 6040. If the flag is in the reset state, control goes to a step 6050 to reset a traction start flag FTT due to the throttle valve 3 and then goes to a step 6060 to set the target throttle opening degree TH as a stepping motor target step number CMD, then followed by a step 6070. The step 6040 is provided in order to check the traction start flag FTT. If it is in the reset state, the decision is made as the initial process at the time of the traction control due to the throttle valve 3, and a step 6100 follows to calculate the current driven wheel torque TW (at the time of the decision of occurrence of slippage).

Detailed Description Text (31):
Furthermore, since the slip ratio is expressed as S=(Vd-Vb)/Vd, when the driven wheel angular velocity is taken as .omega., the following equations can be obtained. ##EQU2## from the equation (2),

Detailed Description Text (33):
Thus, during the execution of the traction control, the driven wheel T to be required is as follows in accordance with the equations (1), (3) and (5). ##EQU4## Here, the factors relating to Ta and Ga are respectively constants which are determined in accordance with the motor vehicle, and the aforementioned torque T can be obtained by the determinations of the driven wheel acceleration Ga and the driven wheel torque Ta at the time of a start of slipping. Since this torque T is obtained by taking into consideration the degree of the friction between the road surface and the wheel tire at the time of a start of slippage, in the case of performing the traction control in order to repress the slippage, if the opening degree of the throttle valve 3 is adjusted so as to realize this torque T from the start of the control, the feedback control for a stable and desirable slip ratio is allowed, thereby ensuring an excellent acceleration performance and a stable running performance.

Detailed Description Text (34):
Therefore, in this step 6200, as described above, a target drive torque FX is obtained on the basis of the driven wheel torque TWQ and the driven wheel initial acceleration GFI at the time of the decision of occurrence of slipping. Here, in most of cases that the traction control is required in order to control the slipping, since the torque at the time of a start of slipping is the maximum torque of the engine, the process in which the driven wheel torque to be obtained in the step 6100 is treated as a constant does not provide a great problem in practice, thereby reducing the load in control.

Detailed Description Text (36):
After the termination of the step 6200, a step 6090 follows to set the traction start flag FTT, then followed by the step 6300. On the other hand, if in the step 6040 the flag FTT has been set, control jumps to the step 6300 without passing through the above-mentioned steps 6100, 6200 and 6090. That is, the steps 6100, 6200 and 6090 are executed only one time immediately after the setting of the traction executing flag FT.

Detailed Description Text (38):
Futhermore, a step 6400 is executed in order to calculate a traction target opening degree THTRC on the basis of the target drive torque FX attained in the above-described step 6300. This calculation process is effected in accordance with an operation shown in FIG. 19 using the linearity between the engine torque and the throttle opening degree as illustrated in FIG. 15. In FIG. 19, in a step 6410, as well as the step 6110 of the FIG. 14 driven wheel torque TW calculation step 6100, the torque saturation opening degree Tsut and the zero torque opening degree Tzero are obtained on the basis of the engine speed Ne. A step 6420 follows to attain a gear ratio TSHFT on the basis of the gear position GP, followed by a step 6430 to obtain the output speed of the output side of the transmission 14 on the basis of the driven wheel speed (rear-right wheel speed VRRF, rear-left wheel speed VRLF) and the gear ratio of the differential gear 15 and then to obtain a torque transformation rate RTOR of the torque converter 13 as a function of the ratio of the obtained output speed and engine speed Ne. A subsequent step 6440 is then executed so as to perform the

first-order transformation of the target drive torque FX in accordance with Tsut and Tzero obtained in the above-mentioned step 6410 and to determine a traction target opening degree THTRC by correcting it with TSHFT and RTOR obtained in the steps 6420 and 6430, thereby terminating this operation.

Detailed Description Text (41):
In this embodiment, when the motor vehicle is running on a rough road surface, the target driven wheel speed Vt is determined from a predetermined value determined as the slip ratio, the required torque FX is set on the basis of the deviation DV with respect to the real driven wheel speed, and the throttle opening degree for realizing this required torque FX is determined at every engine speed using the interval in which ensured is the linearity in the relation between the engine torque and the throttle opening degree (see FIGS. 15 and 16).

Detailed Description Text (42):
Conventionally, since the increase and decrease of the throttle opening degree are directly performed using the driven wheel speed and the non-driven wheel so as to realize a desired slip ratio so that the actual throttle opening degree is controlled to be equal to the target value, when the target driven wheel speed achieving the desirable slip ratio is obtained, the throttle opening degree is fixed accordingly. However, in cases where the motor vehicle is accelerated under the condition that the throttle opening degree is constant, that is, when the engine speed is increased irrespective of the throttle opening degree being constant (TX), since as shown in FIG. 15 the engine torque is lowered in accordance with the increase in the engine speed, the torque which essentially determines the vehicle speed varies in accordance with the acceleration and deceleration. Therefore, in the conventional system, difficulty is encountered to stabilize the control.

Detailed Description Text (44):
The time chart of FIG. 21 shows a prior art technique for the traction control using the throttle valve 3. In the case that the initial value of the throttle opening degree at the time of a start of the feedback control is zero, since the torque is excessively small, non-sharpening state appears. On the contrary, the time chart of FIG. 22 shows the state that the initial value of the throttle opening degree at the time of a start of the feedback control is set to be excessively great. The throttle opening degree and the real driven wheel speed respectively enter into hunting states so as to cause deterioration of the driving feeling. In addition, the time chart of FIG. 23 shows a conventional system in which the target throttle opening degree is directly set on the basis of the driven wheel speed and non-driven wheel speed. In this instance, the follow-up of the real driven wheel speed with respect to the target driven wheel speed is low and the acceleration performance and running stability are insufficient.

Detailed Description Text (46):
Although the above-mentioned embodiment relates to the traction control due to the intake amount adjustment by the throttle valve 3 and the traction control due to the fuel cutting, this is also applicable to braking.

Detailed Description Text (49):
FIG. 27, in detail, shows the braking control base step 7000. In a step 7010, the traction executing flag FT is checked. If the flag FT is "0" indicating that the traction control is not performed, control goes to a step 7020 to reset an initial process flag FTB, then followed by a step 7030 to turn off the master control valve MC 308 and the pressure source returns to the braking pedal 21 side. Then, this operation is terminated after returning to the normal mode to pressure-increase SRL 313 and SRR 314. If the traction executing flag FT is in the set condition, a step 7050 follows to check the initial process flag FTB. If the initial process flag FTB is in the reset condition, the decision is made where the process is the first time after the determination of occurrence of slipping, then followed by a step 7060. In the step 7060, the master control valve MC is set to ON. At this time, since SRL 313 and SRR 314 are ordinarily in the normal modes, respectively, the braking pressure results in being increased. This is for the purpose of increasing pressure in the hydraulic pressure system up to a predetermined value so as to heighten the control response thereafter. In a step 7070, the initial process flag FTB is set, followed by a step 7080 to set an initial process counter CBF to be 2, thereby terminating this

operation. On the other hand, if in the step 7050 the initial process flag FTB is in the set condition, control goes to steps 7090 and 7100 to decrement the counter CBF by one untill the initial process counter CBF becomes zero, thereafter terminating this operation. In this process, the initial pressure rising time is set to be 30 ms. If in the step 7090 the counter CBF is zero, the braking pressure control operation is started. A step 7110 is executed in order to check the value of a SRL active time counter CSRL. If the value thereof is not zero, a step 7120 follows to merely decrement the counter CSRL by one, followed by a step 7200 for the SRR process. If CSRL=0, a step 7130 is executed to check whether a SRL hold counter HSRL is zero. If the counter HSRL is zero indicating termination of the braking pressure process in the previous period, a step 7160 follows to determine the contents of the counter CSRL, counter HSRL and the left-side mode MODL.

Detailed Description Text (52):
According to the traction control based on braking, as the initial acceleration GRL (GRR) of the driven wheel is greater and further the driven wheel acceleration GVRL (GVRR) is greater, that is, when the frictional coefficient between the road surface and the driven wheel tire is small and the degree of slippage of the driven wheel is great, the braking pressure is frequently adjusted so as to quickly control the slippage up to a desired state. In addition, when the slipping control is being achieved so as to decrease the driven wheel acceleration GVRL (GVRR), the interval for adjusting the braking pressure becomes longer, a desired driven wheel speed can be obtained smoothly. Accordingly, by further using the braking control, more appropriate traction control can be ensured.

Detailed Description Text (53):
In addition, for the slip control may be used ignition timing control. In this instance, although the reduced rate of the torque is about 20%, the response is extremely high. Particularly, in the case that the frictional coefficient is small, the control performance is improved by retardation when quickly repressing that the degree of slipping of the driven wheel becomes great. Thus, in the step 5280 of FIG. 9, the process shown in FIG. 32 is performed.

Detailed Description Text (54):
In FIG. 32, a step 5281 is first executed to obtain an ignition timing advance value SA on the basis of the intake pipe pressure PM, engine speed Ne, intake temperature THA and so on in according with a well known ignition timing calculation method. A step 5282 follows to check the traction executing flag FT. If "0", a step 5283 is executed to reset an ignition initial process flag FTS, then followed by a step 5290. If the flag FT is in the set condition, a step 5284 follows to check the flag FTS. If "0" indicating that the process is the first time, a step 5285 is executed in order to obtain a traction retardation initial value KCTS corresponding to the initial acceleration GFI using a map prestored in the ROM 30d and set it to a traction retardation value CTS and further obtain an attenuation value .DELTA.CTS in accordance with the map prestored therein.

Detailed Description Text (55):
Here, in the map, the relation between the traction retardation initial value KCTS, attenuation value .DELTA.CTS and the initial acceleration GFI is as illustrated in FIG. 33.

Detailed Description Text (56):
Returning again to FIG. 32, a step 5286 is then performed to set the flag FTS, followed by a step 5290. If the flag has been in the set state, since the process is not the first time, a step 5287 follows to check the traction retardation value CTS whether CTS>0 indicating the execution of the retardation process. If the process is being effected, a step 5288 follows to decrease the retardation value CTS by .DELTA.CTS. On the other hand, if CTS.ltoreq.0, control goes to a step 5289 to set the retardation value CTS as 0, then followed by a step 5290 to decrease the advance value SA calculated in the step 5281 by the retardation value CTS.

Detailed Description Text (59):
It should be understood that the foregoing relates to only preferred embodiments of the invention, and that it is intended to cover all changes and modifications of the embodiments of the invention herein used for the purposes of the disclosure, which do

not constitute departures from the spirit and scope of the invention. For example, although this embodiment is employed for a gasoline engine motor vehicle, it is also appropriate to be employed for a diesel engine motor vehicle. In the case that the traction control is effected for the diesel engine, as well as the traction control due to the throttle valve 3, the required torque is first determined. In the case of using the VE type pump, the relation between the spill ring position and the engine torque is as illustrated in FIG. 34. Here, the relation varies in accordance with the engine speed Ne and has a upwardly curved characteristic. In order to correct this, in a process corresponding to the step 6100 or 6400 of the throttle control base process, the drive torque at the time of occurrence of slipping is obtained using a two-dimensional map between the spill ring position and the engine speed Ne and further the target spill ring position is obtained in accordance with a two-dimensional map between the required torque and the engine speed Ne, whereby it is possible to perform control with high accuracy as well as the traction control by the throttle valve. Furthermore, in the case of using a line type pump, the control ruck position is similarly controlled.

CLAIMS:

1. A slip control apparatus for use in a motor vehicle, comprising:

an engine mounted on said motor vehicle for generating a motive power to drive said motor vehicle;

first detection means for detecting a speed of a driven wheel of said motor vehicle which is driven by the motive power generated by said engine;

second detection means for detecting a speed of said motor vehicle;

decision means for determining an occurrence of slipping of said driven wheel on the basis of the detection results of said first and second detection means;

third detecting means for detecting the degree of materials combustible as a whole int said engine;

means for quantifying, from the detected speed of the driven wheel, the degree of an acceleration of driven wheel at the time of the determination of occurrence of slipping;

setting means for setting a target driven-wheel speed on the basis of the vehicle speed of said motor vehicle detected by said second detection means when said decision means determines the occurrence of slipping of said driven wheel;

target-torque calculation means for calculating a target torque of said engine based on a deviation between the driven-wheel speed detected by said first detection means and the target driven-wheel speed set by said setting means and, on the result of detection by said third detecting means;

torque adjusting means for adjusting a torque of said engine; and

control means for controlling said torque adjusting means on the basis of the target-torque of said engine calculated by said target-torque calculation means and the degree of acceleration quantified by said quantifying means.

2. A slip control apparatus as claimed in claim 1, wherein said control means includes;

feedback control means for performing feedback control of said torque adjusting means so that the driven wheel speed detected by said first detection means becomes equal to the target driven wheel speed which is set by said setting means.

3. A slip control apparatus as claimed in claim 2, wherein said engine comprises a gasoline engine.

4. A slip control apparatus as claimed in claim 3, wherein said torque adjusting means

comprises a throttle valve of said motor vehicle for adjusting the amount of air taken into said engine.

5. A slip control apparatus as claimed in claim 4, wherein said feedback control means includes:

target torque setting means for determining a target value of a torque generated by said gasoline engine in accordance with the difference between said target driven wheel speed and said driven wheel speed;

target opening degree setting means for setting a target throttle opening degree in correspondence with said target torque; and

throttle valve operating means for operating said throttle valve so as to take said target throttle opening degree.

6. A slip control apparatus as claimed in claim 1, wherein said engine comprises a gasoline engine.

7. A slip control apparatus as claimed in claim 6, wherein said torque adjusting means comprises a solenoid-operated fuel injection valve, and said control means comprises means for determining a time period for stopping supply of a fuel from said fuel injection valve to said engine on the basis of the target torque calculated by said calculation means and controls said fuel injection valve so as to cut off the fuel supply for the determined time period.

8. A slip control apparatus as claimed in claim 6, wherein said torque adjusting means comprises igniting means for igniting mixture of the air and fuel in said engine, and said control means comprises means for determining a retardation value to retard the ignition timing of said ignition means on the basis of the target torque calculated by said calculation means and means for controlling said igniting means so as to be retarded by a time corresponding to the determined retardation value.

9. A slip control apparatus as claimed in claim 1, wherein said torque adjusting means comprises braking means provided with respect to said driven wheel, and said control means comprises means for controlling a braking force of said braking means in accordance with the target torque calculated by said calculation means.

10. A slip control apparatus as claimed in claim 2, wherein said engine comprises a diesel engine.

11. A slip control apparatus as claimed in claim 2, wherein said engine comprises a diesel engine.

12. A slip control apparatus as claimed in claim 10, wherein said torque adjusting means comprises a spill ring for adjusting the amount of a fuel to be supplied to said engine, and said control means comprises means for controlling a position of said spill ring in accordance with the target torque calculated by said calculation means.

13. A slip control apparatus as claimed in claim 11, wherein said torque adjusting means comprises a spill ring for adjusting the amount of a fuel to be supplied to said engine, and said control means comprises means for controlling a position of said spill ring in accordance with target torque calculated by said calculation means.

14. A slip control apparatus as claimed in claim 10, wherein said torque adjusting means comprises a control ruck for controlling the amount of a fuel to be supplied to said engine.

15. A slip control apparatus as claimed in claim 11, wherein said torque adjusting means comprises a control ruck for controlling the amount of a fuel to be supplied to said engine.

16. A slip control apparatus for a motor vehicle, comprising:

an engine mounted on said motor vehicle;

torque adjusting means for adjusting a torque of said engine;

first detection means for detecting a speed of a driven wheel of said motor vehicle;

second detection means for detecting a speed of said motor vehicle;

decision means for determining occurrence of slipping of said driven wheel on the basis of the detection results of said first and second detection means;

third detecting means for detecting the degree of intake of at least one member in a set of materials combustible as a whole into said engine;

means for quantifying, from the detected speed of the driven wheel, the degree of an acceleration of driven wheel at the time of the determination of occurrence of slipping;

setting means for setting a target driven wheel speed in accordance with the detected vehicle speed when said decision means has determined the occurrence of slipping;

target-torque calculation means for calculating a target torque of said engine based on a deviation between the driven-wheel speed detected by said first detection means and the target driven-wheel speed set by said setting means, on the result of detection by said third detecting means, on the result of detection by said third detection means, and on the degree of acceleration quantified by said quantifying means;

second setting means for setting a target position of said torque adjusting means corresponding to said target torque; and

control means for controlling the position of said torque adjusting means in accordance with said target position.

17. A slip control apparatus as in claim 16, wherein said engine comprises a gasoline engine, and said torque adjusting means comprises a throttle valve.

18. A slip control apparatus as in claim 16, wherein said engine comprises a diesel engine, and said torque adjusting means comprises a spill ring.

19. A slip control apparatus as in claim 16, wherein said engine comprises a diesel engine, and said torque control means comprises a control ruck.

20. A slip control apparatus in a motor vehicle having a driven wheel driven by an engine of said motor vehicle, comprising:

a throttle valve for adjusting a torque of said engine;

driven wheel speed detection means for detecting a speed of said driven wheel;

vehicle speed detection means for detecting a speed of said motor vehicle;

slip decision means for determining occurrence of slipping of said driven wheel on the basis of the detected driven wheel speed and the detected vehicle speed;

driven wheel torque detecting means for detecting a torque of said driven wheel;

means for quantifying, from the detected speed of the driven wheel, the degree of an acceleration of driven wheel at the time of the determination of occurrence of slipping;

engine-condition detection means for detecting the degree of intake of at least one member in a set of materials combustible as a whole into said engine;

setting means for setting a target driven-wheel speed on the basis of the detected vehicle speed;

target torque calculating means for calculating a target torque of said engine on the basis of a deviation between the detected driven wheel speed and the set target driven wheel speed, the detected driven wheel torque, the degree of driven wheel acceleration quantified by said quantifying means, and the result of detection by said engine-condition detection means at the time of the occurrence of slipping of said driven wheel;

throttle opening degree calculating means for calculating a target opening degree of said throttle valve on the basis of said target torque; and

throttle valve operating means for operating said throttle valve to take the calculated opening degree.

21. A slip control apparatus as in claim 20, further comprising

engine speed detection means for detecting an engine speed,

said driven wheel torque detection means including means for calculating the present driven wheel torque in accordance with a driven wheel torque characteristic, which is determined on the basis of the relation between said throttle valve opening degree and said engine speed, and

said throttle opening degree calculating means including means for incorporating information provided by the detected engine speed in said calculation of a target opening degree of said throttle valve in accordance with said driven wheel torque characteristic.

22. A slip control apparatus as in claim 20, wherein said target driven wheel torque calculating means includes:

feedback control means for performing feedback control of the target driven wheel torque so that the driven wheel speed detected by said driven wheel speed detection means becomes equal to a target driven wheel speed which is determined in accordance with the vehicle speed detected by said speed detection means; and

initial value setting means for determining an initial value of said feedback control means in accordance with a slipping state of said driven wheel detected at the time of occurrence of slipping of said driven wheel.

23. A slip control apparatus as claimed in claim 21, wherein said target driven wheel torque calculating means includes:

feedback control means for performing feedback control of the target driven wheel torque so that the driven wheel speed detected by said driven wheel speed detection means becomes equal to a target driven wheel speed which is determined in accordance with the vehicle speed detected by said speed detection means; and

initial value setting means for determining an initial value of said feedback control means in accordance with a slipping state of said driven wheel detected at the time of occurrence of slipping of said driven wheel.

24. A slip control apparatus for use in a motor vehicle comprising:

an engine mounted on said motor vehicle for generating a motive power to drive said motor vehicle;

first detection means for detecting a speed of a driven wheel of said motor vehicle which is driven by said motive power generated by said engine;

second detection means for detecting a speed of said motor vehicle;

decision means for determining an occurrence of slipping of said driven wheel on the basis of the detection results of said first and second detection means;

third detecting means for detecting the degree of intake of at least one member in a set of materials combustible as a whole into said engine;

means for quantifying, from the detected speed of the driven wheel, the degree of acceleration of driven wheel at the time of the determination of occurrence of slipping;

setting means for setting a target driven-wheel speed on the basis of the detected speed of said motor vehicle when said decision means determines the occurrence of slipping of said driven wheel;

target-torque calculating means for calculating a target torque of said engine on the basis of a deviation between the detected driven wheel speed and the set target driven wheel, and on the result of detection by said third detection means, said target-torque calculating means determining the initial value of said target torque on the basis of the acceleration detected by said fourth detection means;

torque adjusting means for adjusting a torque of said engine; and

control means for controlling said torque adjusting means on the basis of the target torque of said engine calculated by said calculation means.

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DOCUMENT-IDENTIFIER: US 5119299 A
TITLE: Slip control for automotive vehicle with variable engine speed variation characteristics

Abstract Text (1):
A slip control system employs a plurality of slip control characteristics which may be provided as form of maps. One of the maps is selected depending upon wheel slippage in such a manner that a map having a greater engine speed variation rate with respect to variation of an accelerator position is selected while the wheel slippage is maintained smaller than a predetermined target slippage, and a map having a smaller engine speed variation rate is selected while wheel slippage is greater than the predetermined target slippage. The selected map is compared with a map previously selected at a preceding timing which is variable depending upon a lag time of engine response.

Brief Summary Text (3):
The present invention relates generally to a slip control system for controlling engine driving torque so as to maintain vehicular wheel slippage at an optimal level for optimizing vehicular driving performance. More specifically, the invention relates to a slip control system which employs a map or table for deriving slip control characteristics in response to a variation of operation magnitude of an accelerator depending upon vehicular driving conditions.

Brief Summary Text (5):
In general, it is essential to maintain good road/tire traction for obtaining good vehicular driving performance. For this, wheel slippage has to be maintained within a predetermined optimum range so as to optimize transmission of driving torque from the tread of a vehicular driving wheel to the road surface. Adjustment of driving torque to be delivered to the road wheel is particularly important when the vehicle passes through a road having a surface with substantially low friction, such as wet road, or icy road. In order to maintain wheel slippage at optimum level, Japanese Patent First (unexamined) Publication (Tokkai) Showa 60-43133 proposed a slip control system, in which fuel supply amount for the engine is controlled according to an accelerator position. The disclosed system also includes an arithmetic circuit for comparing rotation speeds of a driving wheel and a driven wheel and for deriving a wheel slippage based on the difference therebetween. When wheel slippage is greater than a predetermined wheel slippage threshold, fuel supply amount is forcingly reduced irrespective of the accelerator position. In such conventional slip control, the fuel supply amount is increased when wheel traction is recovered and thus wheel slippage is decreased to be lower than the wheel slippage threshold, fuel supply amount is resumed to the normal value corresponding to the accelerator position. This tends to cause increased wheel slippage again and thus cause hunting of slip control. Hunting of slip control causes driving torque fluctuations causing jerking on the vehicular body, thereby degrading riding comfort of the vehicle. Furthermore, since the fuel supply amount is controlled irrespective of the accelerator position during slip control mode operation, drive feeling can be degraded because the engine speed is not adjusted linearly corresponding to the accelerator position.

Brief Summary Text (7):
Therefore, it is a principle object of the present invention to provide a slip control system which can solve the problem set forth above.

Brief Summary Text (8):
Another object of the invention is to provide a slip control system which has a plurality of engine speed control characteristics so as to be selected depending upon the vehicle driving condition and thereby optimize the engine speed variation depending upon the vehicle driving condition for optimizing slip control characteristics.

Brief Summary Text (9):
In order to accomplish the aforementioned and other objects, a slip control system, according to the present invention, employs a plurality of slip control characteristics which may be provided in the form of maps. One of the maps is selected depending upon wheel slippage in such a manner that a map having greater engine speed variation rate with respect to variation of an accelerator position is selected while the wheel slippage is maintained smaller than a predetermined target slippage, and a map having smaller engine speed variation rate is selected while wheel slippage is greater than the predetermined target slippage. The selected map is compared with a map previously selected at a preceding timing which is variable depending upon a lag time of engine response.

Brief Summary Text (10):
According to one aspect of the invention, a slip control system for an automotive vehicle having at least one driving wheel associated with an automotive engine via a power train to be driven by the engine driving torque and at least one driven wheel which is free from the engine driving torque, which automotive engine has an engine speed control mechanism associated with a manually operable accelerator to be driven by the latter to a desired position for obtaining desired engine speed, comprises:

Brief Summary Text (14):
According to another aspect of the invention, a slip control system for an automotive vehicle having at least one driving wheel connected to an automotive engine via a power train to be driven by the engine driving torque and at least one driven wheel which is free from the engine driving torque, which automotive engine has a throttle valve associated with a manually operable accelerator to be driven by the latter to a desired position for obtaining a desired throttle valve open angle, comprises:

Brief Summary Text (18):
Preferably, the controller means is responsive to the wheel slippage monitoring means detecting the wheel slippage greater than the first wheel slippage threshold to select one of control characteristics which has lower response characteristics of the throttle valve open angle control means with reference to the control characteristics actually used at a time given period ahead of a time at which the wheel slippage greater than the first wheel slippage threshold is detected. The controller means may compare values representing the control characteristics actually used at the time given period before the time of occurrence of the wheel slippage greater than the first wheel slip criterion and the current control characteristics for performing lowering of control characteristics with respect to one of the control characteristics actually used at the time given period before the time of occurrence of the wheel slippage greater then the first wheel slip criterion which defines lower response characteristics than the other. In practice, the controller means selects the next lower control characteristics to the selected one of the control characteristics accurately used at the time given before the time of occurrence of the wheel slippage greater than the first wheel slip criterion and the current control characteristics in response to the wheel slippage monitoring means detecting the wheel slippage greater than the first wheel slippage criterion.

Drawing Description Text (3):
FIG. 1 is a schematic block diagram of the preferred embodiment of a slip control system according to the present invention;

Drawing Description Text (6):
FIGS. 4(a), 4(b), 4(c) and 4(d) are sequences of a flowchart showing a slip control program to be executed in the slip control system of FIG. 1;

Drawing Description Text (8):
FIG. 6 is a chart showing the variation of slip threshold in relation to rotation

speed of driving wheel; and

Drawing Description Text (9):
FIGS. 7A and 7B are timing charts showing practical operation of the slip control implemented by the preferred embodiment of the slip control system of FIG. 1.

Detailed Description Text (2):
Referring now to the drawings, particularly to FIG. 1, the preferred embodiment of a slip control system, according to the present invention, is applied to an automotive vehicle which has a front engine, rear wheel drive layout. Therefore, the vehicle has an internal combustion engine 10 associated with a power transmission 11 connected to a differential gear unit 13 as a final drive via a propeller shaft 12. The differential gear unit 13 delivers drive shafts 14 and 15 for driving driving wheels 16 and 17. In the shown embodiment, front wheels 18 and 19 are not powered and thus serve as driven wheels. With the shown construction, the engine output torque is input to the power transmission 11 and then transferred to the driving wheels 16 and 17 via the power train including the propeller shaft 12 and the final gear unit 13 to drive the driving wheels at the speed determined by the engine speed and the transmission gear position. On the other hand, since the front wheels 18 and 19 are not powered by the engine driving torque and thus free to rotate, these wheels rotate at a speed corresponding to the vehicle speed.

Detailed Description Text (4):
The control unit 34 comprises a microprocessor which includes an input interface 341, CPU 342, a memory unit 343 and an output interface 344. In order to perform wheel slip dependent throttle position control, wheel speed sensors 30, 31 and 32 are connected to the input interface 341 of the control unit 34. The wheel speed sensor 31 is adapted to monitor the rotation speed of the front-right wheel 18 to produce a front-right wheel speed indicative signal S.sub.vfr. On the other hand, the wheel speed sensor 32 is adapted to monitor the rotation speed of the front-left wheel 19 to produce a front-left wheel speed indicative signal S.sub.vfl. The wheel speed sensor 30 is associated with a rotary disc fixed on the propeller shaft 12 to monitor the rotation speed of the propeller shaft as an average rotation speed of the rear-right and rear-left wheels 16 and 17 and produces a rear wheel speed indicative signal S.sub.vr.

Detailed Description Text (30):
The practical operation to be implemented by the slip control system of FIG. 1 will be described herebelow with reference to FIGS. 4(a) to 4(d) and 5.

Detailed Description Text (31):
FIGS. 4(a) to 4(d) show a sequence of a slip control program stored in the memory unit 343 and to be executed by CPU 342. The shown program is designed to be executed at every fixed timing with a regular interval, e.g. every 20 msec. In order to trigger the shown program, the control unit 34 has an internal clock and an internal timer for measuring an elapsed time to trigger the program at every given period or is connected to an external timing system to bs triggered by a trigger command issued at a given timing.

Detailed Description Text (34):
After deriving the average front wheel speed indicative data D.sub.VF as the driven wheel speed indicative data, a check for the rear wheel speed indicative data D.sub.VR is performed to determine whether the data value is greater than a given value which corresponds to a predetermined vehicular speed, at step 104. In the shown embodiment, the given value represents the vehicular speed of 40 km/h. When the rear wheel speed indicative data D.sub.VR is greater than the given value as checked at the step 104, a wheel slip ratio or wheel slippage S is calculated at step 105. In practice, the wheel slippage S is derived by the following equation:

Detailed Description Text (37):
After the process at the step 154, the process goes to steps 251 to 255, in which slip control characteristics indicative flags MAPFLG are stored over the most recent execution cycles. In the shown embodiment, the slip control characteristics indicative flag MAPFLG is stored for 600 msec. Since the shown program is designed to be executed at every 20 msec., thirty flags are stored. For storing new flag MAPFLG, all

precedingly set twenty-nine flag data are shifted to the next address. Therefore, at a step 291, a flag shift counter value CRT is checked to determine whether it reaches 30. If the flag shift counter value CRT is smaller than 30, the address of the memory address to store than flag data to be shifted is incremented by 1 and the oldest flag data in the greatest memory address is cleared, at a step 252. Thereafter the flag shift counter CRT is incremented by one (1) at a step 253. The steps 251, 252 and 253 form a loop to be repeatedly executed until the counter value CRT reaches 30. On the other hand, when the counter value CRT reaches 30 as checked at the step 251, the process goes to a step 254, in which the oldest flag data MAPFLG is set as a preceding map data MAPOLD. Namely, through the process of the steps 251 to 254, the preceding map data MAPOLD is set by the flag data of 600 msec. ahead. After the process at the step 254, the lag shift counter value CRT is cleared at a step 255.

Detailed Description Text (39):
If the instantaneous accelerator operation magnitude indicative value 1.sub.0 is greater than the lower accelerator operation magnitude threshold value 1.sub.L as checked at the step 250, which implies that the accelerator operation magnitude indicative value 1.sub.0 is smaller than or equal to the upper accelerator operation magnitude threshold valve 1.sub.H and greater than the lower accelerator operation magnitude indicative value 1.sub.L, the current accelerator position variation indicative data .DELTA.L.sub.0 is checked whether it is greater than zero (0) at a step 110. If the currant accelerator position variation indicative value 1.sub.L as checked at the step 110 is greater than zero, the wheel slippage S is compared with a predetermined low wheel slippage threshold S.sub.0 at a step 111. The low wheel slippage threshold S.sub.0 is set at a value (e.g. S=0.1) representative of a criterion of substantially small wheel slippage which does not require slip control even when the throttle valve open angle varies substantially at a normal rate. If the wheel slippage S is smaller than or equal to the low wheel slippage threshold S.sub.0 as checked at the step 111, the throttle valve angular position indicative data .theta..sub.0 is compared with a predetermined maximum throttle open position data .theta..sub.max which represents the maximum throttle valve angular position in a throttle valve angle variation range in the selected control characteristics, at a step 112. When the instantaneous throttle valve angular position indicative data .theta..sub.0 is greater than or equal to the maximum throttle open position data .theta..sub.max, the slip control characteristics indicative flag value MAPFLG is compared with zero (0) at a step 113. The slip control characteristics indicative flag value MAPFLG being equal to zero represents normal throttle valve response characteristics in response to the accelerator operational magnitude. If the slip control characteristics indicative flag value MAPFLG is not zero, i.e. greater than zero, as checked at the step 113, the value of the slip control characteristics indicative flag MAPFLG is decreased or decremented by one (1), at a step 114.

Detailed Description Text (40):
On the other hand, when the instantaneous accelerator operation magnitude indicative data 1.sub.0 is smaller than or equal to the low accelerator operation magnitude threshold 1.sub.L as checked at the step 250, when the current accelerator position variation data .DELTA.L.sub.0 is smaller than or equal to zero as checked at the step 110, when the wheel slippage S is greater then the low wheel slippage threshold S.sub.0 as checked at the step 111, when the instantaneous throttle valve angular position indicative data .theta..sub.0 is smaller then the maximum throttle open position value .theta..sub.max as checked at the step 112, or when the slip control characteristics indicative flag value MAPFLG is zero as checked at the step 113, the process jumps the step 114.

Detailed Description Text (42):
When the wheel slippage S is greater than or equal to the low wheel slippage threshold S.sub.0 as checked at the step 116, and when the timer value TMR is greater than or equal to the time-up threshold as checked at the step 117, the slip control characteristics indicative flag value MAPFLG is checked at a step 161. If the slip control characteristics indicative flag value MAPFLG is greater than zero (0) as checked at the step 161, the value of the slip control characteristics indicative flag MAPFLG is decreased by one (1) at a step 162. On the other hand, when the slip control characteristics indicative flag value MAPFLG is zero as checked at the step 161, the process jumps to the step 162 and clears the timer value TMR at a step 163. On the other hand, after decreasing the value of the slip control characteristics indicative

flag MAPFLG at the step 162, the process goes to the step 163.

Detailed Description Text (43):
At a step 120 which is triggered after one of the steps 250, 114, 119, 163 and 118, the wheel slippage S is compared with a first map down threshold S.sub.1 at a step 120. The first map down threshold S.sub.1 is set at 0.1 in the shown embodiment. Though the shown embodiment takes the first map down threshold S.sub.1 at the equal value to the low wheel slippage threshold S.sub.0, it can be set at a value different from that of the low wheel slippage threshold S.sub.0. If the wheel slippage S as checked at the step 120 is greater than the first map down threshold S.sub.1, a first map down disabling flag FLAGA is checked at a step 121. When the first map down disabling flag FLAGA is not set aa checked at the step 121, the first map down disabling flag FLAGA is set at a step 122. Thereafter, the slip control characteristics indicative flag value MAPFLG is checked whether the value is a maximum value, e.g. seven (7). at a step 123. The maximum value of the slip control characteristics indicative flag value MAPFLG represents the lowest throttle valve angle response characteristics versus variation of the accelerator operation magnitude. When the slip control characteristics indicative flag value MAPFLG is equal to the maximum value, the slip control characteristics indicative flag value is compared with the preceding slip control characteristics indicative flag value MAPOLD, at a step 260. If the slip control characteristics indicative flag value MAPFLG is equal to the maximum value e.g., seven (7), as checked at the step 260, the slip control characteristics indicative flag value MAPFLG is incremented by one (1) at a step 261.

Detailed Description Text (44):
On the other hand, when the slip control characteristics indicative flag value MAPFLG, as checked at the step 260, is smaller than the preceding slip control characteristics indicative flag value MAPOLD, the preceding slip control characteristics indicative flag value is compared with the maximum slip control characteristics indicative flag value at a step 262. When the preceding slip control characteristics indicative flag MAPOLD is smaller than the maximum slip control characteristics flag value, e.g. seven, the preceding slip control characteristics indicative flag MAPOLD is incremented by one (1) at a step 263. At the step 263, the slip control characteristics indicative flag value MAPFLG is set at the value of the preceding slip control characteristics indicative flag value MAPOLD. On the other hand, when the preceding slip control characteristics indicative flag value MAPOLD, as checked at the step 262, is equal to the maximum slip control characteristics indicative flag value, the slip control characteristics indicative flag value MAPFLG is set at the maximum value, e.g. seven (7), at a step 264.

Detailed Description Text (46):
At a step 126, the wheel slippage S is compared with a second map down threshold S.sub.2. In the shown embodiment, the second map down threshold S.sub.2 is set at a value greater than the first map down threshold S.sub.1 and practically set at a value 0.3. When the wheel slippage S as checked at the step 126 is greater than the second map down threshold S.sub.2, a second map down disabling flag FLAGB is checked at a step 127. If the second map down disabling flag FLAGB is not set as checked at the step 127, the second map disabling flag FLAGB is set at a step 128. Thereafter, the slip control characteristics indicative flag value MAPFLG is checked at a step 129. A check at the step 129 is performed by comparing the slip control characteristics indicative flag value MAPFLG with the maximum slip control characteristics indicative flag value, e.g. seven (7). When the slip control characteristics indicative flag value MAPFLG is smaller than the maximum value, the flag value is incremented by one (1) at a step 130. Thereafter, the process goes to a step 140, in which a slip control characteristics indicative data MAPSET is set at a value corresponding to the slip control characteristics indicative flag value MAPFLG. At the step 140, setting of the slip control characteristics indicative data MAPFLG is performed by selecting one of eight maps respective of which shows the variation characteristics of throttle valve angular position relative to the variation of the accelerator position. The selection of one of the maps is done by the slip control characteristics indicative flag value MAPFLG. When the wheel slippage S is smaller than or equal to the second map down threshold S.sub.2, the second map down disabling flag FLAGB is reset at a step 131.

Detailed Description Text (47):

On the other hand, when the slip control characteristics indicative flag value MAPFLG, as checked at the step 123, is the maximum value, e.g. seven (7), after setting the slip control characteristics indicative flag value to seven at the step 264, or after resetting the second map down disabling flag FLAGB at the step 131, the process goes to the step 140.

Detailed Description Text (48):
After setting the slip control characteristics indicative data MAPSET at a step 140, the instantaneous accelerator operation magnitude indicative data l.sub.0 is compared with the low accelerator operation magnitude threshold l.sub.L, at a step 164. When the accelerator operation magnitude indicative data l.sub.0 is greeter than the low accelerator operation magnitude threshold is l.sub.L is checked at the step 164, the current accelerator position difference indicative data .DELTA.L.sub.0 is compared with zero (0) at a step 155. If the current accelerator position difference indicative data .DELTA.L.sub.0, as checked at the step 155, is greater than zero, the preceding accelerator position difference indicative data .DELTA.L.sub.1 is compared with zero (0) at a step 156. On the other hand, when the current accelerator position difference indicative data .DELTA.L.sub.0 is smaller than or equal to zero (0) is checked at the step 155, the preceding accelerator position difference indicative data .DELTA.L.sub.0 is compared with zero (0) at a step 157.

Detailed Description Text (53):
The target throttle open angle indicative value .theta..theta. is compared with a maximum throttle angle indicative value .theta..sub.max which is derived according to the slip control characteristics set at the step 140, at a step 181. When the target throttle open angle indicative value .theta..theta. is greater than the maximum throttle open angle indicative value .theta..sub.max, the target throttle open angle indicative value .theta..theta. is modified to the value corresponding to the maximum throttle angle indicative value .theta..sub.max to derive a modified target throttle open angle indicative value as a throttle open angle value .theta.*. at a step 182. On the other hand, when the target throttle open angle indicative value .theta..theta. is smaller than or equal to the maximum throttle angle indicative value .theta..sub.max, the target throttle open angle indicative value is compared with a minimum throttle open angle indicative value .theta..sub.min, at a step 183. When the target throttle open angle indicative value .theta..theta. is smaller than the minimum throttle open angle indicative value .theta..sub.min as checked at the step 183, the target throttle open angle indicative value is modified to the value corresponding to the minimum throttle open angle indicative value to derive the modified target throttle valve open angle indicative value as the throttle open angle value .theta.* , at a step 184. On the other hand, when the target throttle valve open angle indicative value .theta..theta. is greater than or equal to the minimum throttle valve open angle indicative value .theta..sub.min as checked at the step 183, the target throttle valve open angle indicative value as derived at the step 180 is set as the throttle open angle value .theta.*, at a step 185.

Detailed Description Text (56):
Here, the practical slip control process to be performed by the shown embodiment of the slip control system, according to the present invention, will be discussed herebelow with reference to FIGS. 7A and 7B. The shown example is directed to the vehicular driving condition through a stacked and pressured snow and an icy road. On FIGS. 7A and 7B, the vehicle enters into the icy road after traveling on the pressured snowy road. While the vehicle travels on the snowy road, it is assumed that the wheel slippage S is maintained smaller than or equal to 0.1. During vehicular driving, slip control characteristics indicative maps vary gradually from No. 7 map which orders the lowest response characteristics to No. 1 map which orders the second highest response characteristics. The stepwise increasing or rising of the response characteristics is shown in the range of time before a time to in FIGS. 7A and 7B. This is done by repeating the steps 116 to 118 and 161 to 163 in FIG. 4b.

Detailed Description Text (58):
This throttle valve open angle reducing technology is advantageously introduced in the preferred process of control for effective recovery of tire traction without causing hunting and without substantial degradation of the engine acceleration characteristics. Namely, when map down operation at the time t.sub.0 is performed with respect to the No. 1 map which is selected to the time t.sub.0 and to select No. 2

map, reduction of throttle valve angle is apt to be insufficient to maintain unacceptable wheel slippage or to cause excessively great wheel slippage in a short period to cause hunting of control. On the other hand, when map down operation at the time t.sub.0 is performed for selecting the No. 7 map, substantial reduction of the throttle valve open angle is caused to serious degradation of the engine acceleration characteristics to degrade drivability of the vehicle.

Detailed Description Text (59):
By selecting the No. 5 map as the slip control characteristics for preventing the excessive wheel slippage, tire traction is resumed. Therefore, the wheel slippage S is reduced to be smaller than S.sub.1. Therefore, the map selection is cyclically done to select higher response characteristics defining maps. In the shown embodiment, the map number is reduced from No. 5 to No. 3 until a time t.sub.1. Between t.sub.0 and t.sub.1, the road surface condition changes from a snowy road to an icy road. Because of lower friction on the road surface on the icy road in comparison with that of the snowy road and increasing of the throttle valve open angle, wheel slippage S increases to become greater than or equal to the first map down threshold S.sub.1 the time t.sub.1. In response to this, a map down operation is performed to lower response characteristics. At this time, since the map selected at a time 600 msec. before the time t.sub.1 is No. 1 map which represents higher response characteristics than the current map, i.e. No. 3 map, a map down operation is performed with respect to the current No. 3 map through the steps 260 to 263 of FIG. 4.

Detailed Description Text (61):
As will be seen herefrom, each map used in the preferred embodiment of the slip control system defines an accelerator operation range and basically corresponds to the throttle valve angular position with a variable throttle angle variation gradient, substantially linear engine acceleration characteristics relative to the operation magnitude can be obtained to maintain good drive feeling. Furthermore, since the throttle open angle variation relative to the relative variation of the accelerator is set in non-linear characteristics as shown in FIG. 3, enhancement of good acceleration characteristics can be achieved. In addition, since the shown embodiment derives wheel slippage simply based on the difference of front and rear wheel speeds at a low vehicle speed range, response characteristics of the slip control system can be lowered so as not to cause unnecessary slip control in the low vehicle speed range where wheel slippage may not cause serious problem. This can maintain the acceleration characteristics in the low vehicle speed range at a reasonably high level.

Detailed Description Text (63):
Additionally, since the shown embodiment of the slip control system limits throttle valve variation range with maximum value, unacceptable rapid increasing of the throttle valve open angle which may cause substantial change of engine driving torque can be successfully prevented. Also, in a range where the accelerator operation magnitude is greater than or equal to the upper accelerator operation magnitude threshold, an increase of throttle valve response characteristics is performed when wheel slippage is maintained lower than the wheel slippage threshold S.sub.0 for a period longer than a given period T.sub.0, and a substantial and rapid increase of wheel slippage can be successfully prevented to provide good vehicle acceleration characteristics fitting with the driver's demand. Furthermore, according to the shown embodiment, once the map down operation is performed, further map down operation will not be performed unless the wheel slippage becomes greater than the second map down threshold which is much greater than the first map down threshold and a map up operation will not be performed unless the map up condition is satisfied. Therefore, hunting in map up and down operation can be successfully prevented.

Detailed Description Text (64):
As can be seen hereabove, the slip control system according to the present invention achieves all of the objects and advantages sought therefor.

Detailed Description Text (66):
For example, the maps to be utilized in the slip control system are not limited to the shown ones but can be modified in various fashions. For instance, though the shown embodiment employs maps, each having maximum and minimum values, it is possible to use maps having only maximum values. In addition, though a plurality of maps are used in the shown embodiment, a single map containing throttle open angle variation

characteristics in combination of various maps can be employed. Furthermore, it is possible to determine the reduction ratio of the throttle valve response characteristics (increasing of map number in the shown embodiment) depending upon variation rate of the wheel slippage. In addition, though the shown embodiment employs single characteristics for determining the throttle open angle position in relation to the relative accelerator operation magnitude, it is possible to employ a plurality of characteristics as shown by broken lines in FIG. 3. Of course, it is also possible to employ throttle fully close technology in combination with the foregoing variable throttle response characteristics technology. In such case, fully closing control for the throttle valve may be performed when the wheel slippage becomes greater than the second map down threshold after one map down operation is performed in response to the wheel slippage being greater than the first map down threshold.

CLAIMS:

1. A slip control system for an automotive vehicle having at least one driving wheel connected to an automobile engine via a power train to be driven by the engine driving torque, said automotive engine having an engine speed control means driven by a manually operable accelerator to a desired position for obtaining a desired engine speed, comprising:

an accelerator servo system for driving said engine speed control means in response to an engine speed control command;

wheel slippage monitoring means for monitoring wheel slippage on said driving wheel on the basis of a monitored vehicle speed and a monitored speed at said driving wheel;

memory means for storing a plurality of preset mutually distinct engine speed control characteristics, each defining response characteristics of said engine speed control means relative to operation magnitudes of said accelerator;

controller means for deriving said engine speed control command based upon the operation magnitude of said accelerator and according to one of said stored control characteristics, said controller means selecting one of said stored control characteristics to increase the response characteristics for a higher response of said engine speed control means relative to the operation magnitude of said accelerator as long as said wheel slippage monitored by said wheel slippage monitoring means is maintained lower than a first wheel slippage threshold, and to lower the response characteristics for lower response of said engine speed control means relative to the operation magnitude of said accelerator in response to said wheel slippage monitoring means detecting the wheel slippage as being greater than said first wheel slippage threshold;

wherein said controller means is responsive to said wheel slippage monitoring means detecting the wheel slippage greater than said first wheel slippage threshold to compare values representing one of the stored control characteristics that was actually used at the given time period before the occurrence of a wheel slippage greater than the first wheel slippage threshold and one of the stored control characteristics that is currently used, respectively, so as to identify a lower control characteristic between said compared control characteristics that defines lower response characteristics of said engine speed control means, for performing a lowering of the response characteristics by selecting a further lower control characteristic that defines further lower response characteristics with respect to said identified lower control characteristic.

2. A slip control system as set forth in claim 1, wherein said lowering of the response characteristics is performed such that said selected further lower control characteristic defines the next lower response characteristics with respect to said identified lower control characteristic.

3. A slip control system as set forth in claim 2, wherein said controller means disables the lowering of the response characteristics during a period in which the wheel slippage is continuously greater than said first wheel slippage threshold after once lowering the response characteristics and wherein said controller means is responsive to said wheel slippage subsequently increasing to exceed a second wheel

slippage threshold that is set at a greater value than said first wheel slippage threshold to further lower the response characteristics by selecting a corresponding further lower control characteristic.

4. A slip control system for an automotive vehicle having at least one driving wheel connected to an automotive engine via a power train to be driven by the engine driving torque, said automotive engine having an engine speed control means driven by a manually operable accelerator to a desired position for obtaining a desired engine speed, comprising:

an accelerator servo system for driving said engine speed control means in response to an engine speed control command;

wheel slippage monitoring means for monitoring wheel slippage on said driving wheel on the basis of a monitored vehicle speed and a monitored speed at said driving wheel;

memory means for storing a plurality of preset mutually distinct engine speed control characteristics, each defining response characteristics of said engine speed control means relative to operation magnitudes of said accelerator;

controller means for deriving said engine speed control command based upon the operation magnitude of said accelerator and according to one of said stored control characteristics, said controller means selecting one of said stored control characteristics to increase the response characteristics for a higher response of said engine speed control means relative to the operation magnitude of said accelerator as long as said wheel slippage monitored by said wheel slippage monitoring means is maintained lower than a first wheel slippage threshold, and to lower the response characteristics for lower response of said engine speed control means relative to the operation magnitude of said accelerator in response to said wheel slippage monitoring means detecting the wheel slippage as being greater than said first wheel slippage threshold; and

wherein each of said stored plurality of control characteristics includes a maximum allowable engine speed control command value for a given frictional coefficient.

5. A slip control system as set forth in claim 4, wherein said stored plurality of control characteristics include the highest control characteristics defining the highest response characteristics of said engine speed control means and having the greatest maximum allowable engine speed control command value, and the lowest response characteristics defining the lowest response characteristics of said engine speed control means and having the smallest maximum allowable engine speed control command value.

6. A slip control system as set forth in claim 4, wherein each of said stored plural control characteristics further defines a minimum engine speed control command value, and wherein each said engine speed control command value is derived at a value between said minimum and maximum values of the selected control characteristic.

7. A slip control system as set forth in claim 6, wherein each said engine speed control command value is derived based on the magnitude of the manual operation of the accelerator, the selected control characteristic, and a variation magnitude of the accelerator operation.

8. A slip control system as set forth in claim 7, wherein said memory means includes a further engine speed control characteristic that defines variation characteristics of said engine speed control means in terms of said variation magnitude of the accelerator operation, and wherein said controller means derives a required variation magnitude of said engine speed control means based on said variation magnitude of the accelerator operation using said further engine speed control characteristic, said derived variation magnitude of said engine speed control means being added to a reference magnitude of said engine speed control means so as to derive said engine speed control command value, said engine speed control command value having upper and lower limits respectively defined by said maximum and minimum values of the selected control characteristic.

9. A slip control system as set forth in claim 8, wherein said reference magnitude of the engine speed control means is updated by an instantaneous magnitude of the engine speed control means at an engine operating condition determined by monitoring the variation magnitude of the accelerator operation.

10. A slip control system for an automotive vehicle having at least one driving wheel connected to an automotive engine via a power train to be driven by the engine driving torque, said automotive engine having an engine speed control means driven by a manually operable accelerator to a desired position for obtaining a desired engine speed, comprising:

an accelerator servo system for driving said engine speed control means in response to an engine speed control command;

wheel slippage monitoring means for monitoring wheel slippage on said driving wheel on the basis of a monitored vehicle speed and a monitored speed at said driving wheel;

memory means for storing a plurality of preset mutually distinct engine speed control characteristics, each defining response characteristics of said engine speed control means relative to operation magnitudes of said accelerator;

controller means for deriving said engine speed control command based upon the operation magnitude of said accelerator and according to one of said stored control characteristics, said controller means selecting one of said stored control characteristics to increase the response characteristics for a higher response of said engine speed control means relative to the operation magnitude of said accelerator as long as said wheel slippage monitored by said wheel slippage monitoring means is maintained lower than a first wheel slippage threshold, and to lower the response characteristics for lower response of said engine speed control means relative to the operation magnitude of said accelerator in response to said wheel slippage monitoring means detecting the wheel slippage as being greater than said first wheel slippage threshold and;

wherein said controller means is responsive to said wheel slippage monitoring means detecting a wheel slippage smaller than a third wheel slippage threshold for selecting higher control characteristics.

11. A slip control system as set forth in claim 10, wherein said controller means selects higher control characteristics when said wheel slippage monitoring means continuously detects said wheel slippage as being smaller than said third wheel slippage threshold for a given period of time.

12. A slip control system as set forth in claim 11, wherein said controller means cyclically selects higher control characteristics as long as said wheel slippage is maintained smaller than said third wheel slippage threshold.

13. A slip control system as set forth in claim 12, wherein said third wheel slippage threshold is set at an equal value to said first wheel slippage threshold.

14. A slip control system for an automotive vehicle having at least one driving wheel connected to an automotive engine via a power train to be driven by the engine driving torque, said automotive engine having a throttle valve driven by a manually operable accelerator to a desired position for obtaining a desired throttle value open angle, comprising:

an accelerator servo system for driving said throttle valve in response to a throttle valve open angle control command;

wheel slippage monitoring means for monitoring wheel slippage on said driving wheel on the basis of a monitored vehicle speed and a monitored speed at said driving wheel;

memory means for storing a plurality of preset mutually distinct engine speed control characteristics, each defining response characteristics of said engine speed control means relative to operation magnitudes of said accelerator;

controller means for deriving said throttle valve open angle control command based upon the operation magnitude of said accelerator and according to one of said stored control characteristics, said controller means selecting one of said stored control characteristics to increase the response characteristics for a higher response of said throttle valve relative to the operation magnitude of said accelerator as long as said wheel slippage monitored by said wheel slippage monitoring means is maintained lower than a first wheel slippage threshold, and to lower the response characteristics for lower response of said throttle valve relative to the operation magnitude of said accelerator in response to said wheel slippage monitoring means detecting the wheel slippage as being greater than said first wheel slippage threshold;

wherein said controller means is responsive to said wheel slippage monitoring means detecting the wheel slippage greater than said first wheel slippage threshold to select a lower control characteristic that defines lower response characteristics of said throttle valve open angle control means with reference to one of the stored control characteristics that was actually used at a given time period before a time at which the wheel slippage greater than said first wheel slippage threshold is detected and;

wherein said controller means is responsive to said wheel slippage monitoring means detecting the wheel slippage greater than said first wheel slippage threshold to compare values representing one of the stored control characteristics that was actually used at the given time period before the occurrence of a wheel slippage greater than the first wheel slippage threshold and one of the stored control characteristics that is currently used, respectively, so as to identify a lower control characteristic between said compared control characteristics that defines lower response characteristics of said throttle valve open angle control means, for performing a lowering of the response characteristics by selecting a further lower control characteristics that defines further lower response characteristics with respect to said identified lower control characteristic.

15. A slip control system as set forth in claim 14, wherein said lowering of the response characteristics is performed such that said selected further lower control characteristic defines the next lower response characteristics with respect to said identified lower control characteristic.

16. A slip control system as set forth in claim 15, wherein said controller means disables the lower of the response characteristics during a period in which the wheel slippage is greater than said first wheel slippage threshold after once lowering the response characteristics, and wherein said controller means is responsive to said wheel slippage subsequently increasing to exceed a second wheel slippage threshold that is set at a greater value than said first wheel slippage threshold to further lower the response characteristics by selecting a corresponding further lower control characteristic.

17. A slip control system for an automotive vehicle having at least one driving wheel connected to an automotive engine via a power train to be driven by the engine driving torque, said automotive engine having a throttle valve driven by a manually operable accelerator to a desired position for obtaining a desired throttle valve open angle, comprising:

an accelerator servo system for driving said throttle valve in response to a throttle valve open angle control command;

wheel slippage monitoring means for monitoring wheel slippage on said driving wheel on the basis of a monitored vehicle speed and a monitored speed at said driving wheel;

memory means for storing a plurality of preset mutually distinct engine speed control characteristics, each defining response characteristics of said engine speed control means relative to operation magnitudes of said accelerator;

controller means for deriving said throttle valve open angle control command based upon the operation magnitude of said accelerator and according to one of said stored control characteristics, said controller means selecting one of said stored control characteristics to increase the response characteristics for a higher response of said

throttle valve relative to the operation magnitude of said accelerator as long as said wheel slippage monitored by said wheel slippage monitoring means is maintained lower than a first wheel slippage threshold, and to lower the response characteristics for lower response of said throttle valve relative to the operation magnitude of said accelerator in response to said wheel slippage monitoring means detecting the wheel slippage as being greater than said first wheel slippage threshold and;

wherein each of said stored plural control characteristics includes a maximum allowable throttle valve open angle control command value for a given frictional coefficient.

18. A slip control system as set forth in claim 17, wherein said stored plural control characteristics includes the highest control characteristics defining the highest response characteristics of said throttle valve and having the greatest maximum throttle valve open angle control command value and the lowest response characteristics defining the lowest response characteristics of said throttle valve and having the smallest maximum throttle valve open angle control command value.

19. A slip control system as set forth in claim 17, wherein said controller means selects higher control characteristics when said wheel slippage monitoring means continuously detects said wheel slippage as being smaller than said third wheel slippage threshold for a given period of time.

20. A slip control system as set forth in claim 19, wherein said controller means cyclically selects higher control characteristics as long as said wheel slippage is maintained smaller than said third wheel slippage threshold.

21. A slip control system as set forth in claim 20, wherein said third wheel slippage threshold is set at an equal value to said first wheel slippage threshold.

22. A slip control system for an automotive vehicle having at least one driving wheel connected to an automotive engine via a power train to be driven by the engine driving torque, said automotive engine having a throttle valve driven by a manually operable accelerator to a desired position for obtaining a desired throttle valve open angle, comprising:

an accelerator servo system for driving said throttle valve in response to a throttle valve open angle control command;

wheel slippage monitoring means for monitoring wheel slippage on said driving wheel on the basis of a monitored vehicle speed and a monitored speed at said driving wheel;

memory means for storing a plurality of preset mutually distinct engine speed control characteristics, each defining response characteristics of said engine speed control means relative to operation magnitudes of said accelerator;

controller means for deriving said throttle valve open angle control command based upon the operation magnitude of said accelerator and according to one of said stored control characteristics, said controller means selecting one of said stored control characteristics to increase the response characteristics for a higher response of said throttle valve relative to the operation magnitude of said accelerator as long as said wheel slippage monitored by said wheel slippage monitoring means is maintained lower than a first wheel slippage threshold, and to lower the response characteristics for lower response of said throttle valve relative to the operation magnitude of said accelerator in response to said wheel slippage monitoring means detecting the wheel slippage as being greater than said first wheel slippage threshold and;

wherein said controller means is responsive to said wheel slippage monitoring means detecting wheel slippage smaller than a third wheel slippage threshold for selecting higher control characteristics.

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TITLE: Method for controlling automatic transmissions

Brief Summary Text (12):
(3) Under conditions when the driving wheel looses traction due to spinning or locking, conventional control methods for continuously variable transmissions adjust to the wheel speed in the spinning or locked condition. Consequently, the ratio is adjusted to an inappropriate level such that engine braking is inappropriately applied or acceleration is compromised when the wheel again grips the driving surface.

Brief Summary Text (13):
Once a driving wheel slips relative to the ground or driving surface because of an excessively high driving force being transmitted to the driving wheel, rotational speed of the engine (Ne) rises inappropriately and the transmission ratio (R) is shifted to a low ratio. Therefore, when the driving wheel again grips the driving surface, the rotational speed (Ne) of the engine is brought down, resulting in power loss. On the other hand, if wheel slippage is caused by excessive braking force such that the driving wheel may lock or approach the locked condition, the engine speed is lowered and the control circuit accommodates that condition by readjusting the ratio to raise the engine speed. Once in this condition, the vehicle is unintentionally slowed down when the driving wheel regrips the surface.

Brief Summary Text (15):
When a vehicle jumps and the driving wheel comes off the ground, the driving wheel looses traction and the rotational speed of the engine momentarily increases. According to conventional control methods for continuously variable transmissions, the transmission ratio is then reduced. The vehicle then returns to the ground and the wheel slows to match the vehicle speed. With the adjusted ratio, the driving wheel does not regrip the ground quickly and acceleration is compromised. Further, the rotational speed of the engine momentarily slows when the wheel regrips the surface resulting in a further compromise to acceleration. In a condition where the throttle is closed while the vehicle is in the jump, the rotational speed of the engine decreases and the transmission ratio becomes higher. Under this circumstance, when the vehicle regrips the driving surface, braking may be experienced In both cases, performance is lost.

Brief Summary Text (21):
A second or special stage control selects and sets a transmission ratio and transmission coefficient when the vehicle is no longer in the initial stage control and when the driving force of the engine is disconnected from traction with the driving surface Such a special stage control would be applied when the vehicle is in a jump, when the driving wheel is locked by braking or when the driving wheel is spinning due to excessive acceleration. Such a condition would also apply when the engine is disengaged from the transmission by actuation of a clutch. In such cases, the transmission is controlled so that shock is minimized when the driving force transmission path between the engine and traction of the driving wheel is again complete. The special stage control may be achieved by synchronizing the rotational speed of the driving wheel to the actual speed of the vehicle.

Brief Summary Text (23):
Accordingly, it is a principal object of the present invention to provide an improved

method for controlling a continuously variable automatic transmission. Such methods as may be achieved according to the present invention may facilitate starting the vehicle by shoving, contribute to efficient acceleration under various driving conditions, minimize shock upon recovery of traction and avoid shock during clutching. Further objects and advantages of the present invention will appear hereinafter.

Drawing Description Text (26):
FIG. 26 is a flow chart showing a modified procedure for acceleration slip control.

Drawing Description Text (28):
FIG. 28 is a flow chart showing a control procedure in lock-slip control.

Detailed Description Text (81):
The special stage control is performed on condition that the state of the vehicle gets out of the initial stage control. The special stage control corresponds to a status wherein a transmission of the driving force is disconnected between the engine and the ground, for example, while the vehicle is jumping, slipping, or the clutch is set off. Under such conditions, transmission ratio is controlled so that the rotational speed of the driving wheel coincides with an actual speed of the vehicle in order that the driving wheel recovers a grip of the ground most quickly and smoothly. The special stage control includes one or a plurality of the following operations such as a jumping control, a lock-slip control, and an inertial, running control which are denoted by having a letter (b) in the name.

Detailed Description Text (94):
According to the above-mentioned procedure, transmission ratio (R) is set within a prescribed range of values between (RL) and (RT) according to a judgement that the engine is to be started by shoving the vehicle. The range of transmission ratio is determined so as to give suitable torque and speed to the engine by shoving the vehicle by human power. The shoving start procedure is as follows. First, the vehicle is shoved to move by human power while setting off the clutch by an operation of a clutch lever. Next, when the speed of the vehicle reaches a certain level, the clutch is set on suddenly. By the operation, inertial moment of the vehicle is transmitted to the engine to rotate the crankshaft and the engine is started. If the transmission ratio in the shoving start is too high, the vehicle is braked suddenly and the driving wheel slips when the clutch is set on. So, the engine is not started effectively. On the other hand, if the transmission ratio is too low, rotation of the engine is insufficient to get started. Therefore, the transmission ratio has to be set at an intermediate value, corresponding to a second or a third gear ratio in a manual transmission, in the shoving start control. The engine can be also started by the shoving start control when the engine stops inadvertently while the vehicle is running at a low speed. In such a case, the transmission ratio is reset at a value which is suitable to restart the engine automatically. Therefore, the engine is restarted without any operation of the driver.

Detailed Description Text (124):
First, the control unit (U) judges whether or not the driving wheel is in contact with the ground, step (b-1). If the judgement is positive, the control proceeds to a lock-slip control (b-3). If the judgement is negative, the control proceeds to the following steps.

Detailed Description Text (142):
4.3.8 Lock-Slip Control (step b-3, b-4)

Detailed Description Text (143):
A lock-slip control is performed on condition that the driving wheel is in contact with the ground at step (b-1), FIG. 28. In the lock-slip control, it is judged whether or not the driving wheel looses a grip of the ground by an excessive driving force or an excessive braking force, first step (b-3). Then, the transmission ratio is adjusted so that the driving wheel recovers the grip most quickly and smoothly on condition that the driving wheel has lost grip of the ground, in step (b-4). The above-mentioned steps (b-3) and (b-4) further comprise sub-steps explained as follows.

Detailed Description Text (151):
In step (b-402), the control unit judges whether or not VRR-VFR is lower than C4 for

longer than a prescribed time interval. The control unit judges that the speed of the motorcycle has not changed much, and proceeds the control to step (b-403) on condition that the judgement is negative. If the control unit judges that the speed of the motorcycle has changed during the slip, and therefore requires a readjustment of the transmission ratio, it proceeds the control to step (b-407), in step (b-402).

Detailed Description Text (155):
In step (b-409) succeeding step (b-408), the control unit (U), sends a control signal to the transmission ratio varying mechanism so that the transmission ratio is altered to coincide with the objective transmission ratio. Generally, the transmission ratio is raised in this case because the driving wheel is slipping due to an excessive braking force and the speed of the motorcycle is being lowered from the speed before the occurrence of the slip. Then the control is returned to step (a-b 1).

Detailed Description Text (156):
The control enters in step (b-404) on condition that VRR-VF is larger than a prescribed value C1, that is, when a time derivative of rotational speed of the driving wheel exceeds the prescribed value. In the step, the control unit (U) calculates a difference of the rotational speed VRR of the driving wheel and the rotational speed VFR of the non-driving wheel, and compares the difference with a prescribed value C3 which is normally a positive value. If VRR-VFR is lower than C3, the control unit judges that the slip is not substantially large, and return the control to step (b-33). Otherwise, the control unit (U) judges that the driving wheel is slipping due to an excessive acceleration, requires a re-adjustment of the transmission ratio, and proceeds to step (b-405).

Detailed Description Text (162):
Then, in step (b-413), the control unit (U) send a control signal to the transmission ratio varying mechanism so that the transmission ratio coincides with the, objective transmission ratio. In this case, generally, the transmission ratio is raised because the speed of the motorcycle is decreasing and the rotational speed of the driving wheel is too high compared to the actual speed of the motorcycle. Subsequently, the control is returned to step (a-1).

Detailed Description Text (166):
Effects of the above-mentioned lock-slip control will be explained, hereinafter, referring to an operation in a motorcycle passing through a muddy ground.

Detailed Description Text (167):
When a motorcycle is passing over small obstacles and dips and the rotational speed of the driving speed with respect to time is not varying over a certain value, the transmission ratio is kept unchanged as long as the lock-slip control is concerned (steps b-3, b-403).

Detailed Description Text (168):
When a motorcycle arrives at a muddy area in the ground and the driving wheel starts spinning thereon, rotational speed of the engine and of the driving wheel jumps up abruptly as the driving wheel looses a grip of the ground. It occurs because the maximum friction force is smaller on a muddy ground compared with a normal or firm ground. At a same time, speed of the motorcycle and rotational speed of the non-driving wheel begin to decrease. In such a case, it is important to give the driving wheel a moderate driving force because an excessively high driving force increases the spin inadvertently and an insufficient driving force does not push the motorcycle out of the mud. According to the lock-slip control, the control unit finds that the driving wheel has lost a grip of the ground on the basis that the rotational speed of the driving wheel jumps up abruptly (steps b-31, b-32), and finds that an excessive driving force is being transmitted to the driving wheel (step b-404). Then, if the speed of the motorcycle is not lowered much yet (step b-405), the transmission rate is kept as it has been so as to give the driving wheel a driving force suitable to get out of the muddy place (step b-406). If the speed of the motorcycle has already dropped more than a certain level, transmission ratio is increased so that the driving wheel recaptures a grip of the ground and enough driving force is transmitted to the driving wheel (steps b-411 to b-413).

Detailed Description Text (170):

When an excessive driving force is transmitted to the driving wheel and the motorcycle is accelerating as the driving wheel is half slipping, transmission has to be adjusted so that the slip is minimized and a maximum driving force is transmitted to the ground. In such a case, slip of the driving wheel as the motorcycle is accelerating is detected by the control unit on the basis that the rotational speed of the driving wheel is increasing (step b-31) and larger than that of the non-driving wheel (step b-32), and rotational speed of the non-driving wheel is increasing (step b-405, 410). Then, a suitable transmission ratio is calculated on the basis of the rotational speed of the non-driving wheel and the transmission ratio is reset so as to recover a grip as soon as possible or to minimize a shock when a grip is recovered.

Detailed Description Text (171):
Because the above-mentioned lock-slip control is performed according to the jump control, mismatching of the rotational speed of the driving wheel with that of the non-driving wheel during a jump is treated correctly by the jump control procedure. Thus an operability of the system is increased.

Detailed Description Text (182):
On the other hand, the dotted line in FIG. 27(A) shows a maximum speed change of the vehicle calculated theoretically supposing that the vehicle starts accelerating at its maximum possible acceleration, keeping a grip of the ground, at time T0. Between T0 and T1, the rotational speed of the driving wheel increases more rapidly than a calculated maximum value which indicates that the driving wheel is spinning and the rotational speed thereof does not represent a correct speed of the vehicle. While in FIG. 27(B), the dotted line parallel to the zero line shows a theoretically obtained maximum possible acceleration of the vehicle. The apparent acceleration calculated from the rotational speed of the driving wheel becomes higher than the theoretical maximum level in a certain time interval between T0 and T2. It is detected, by comparing the above-mentioned solid line and dotted line, that the driving wheel is slipping. Further, detection of slipping is simpler when based on the acceleration than on the speed because a simple comparison of apparent acceleration with, a prescribed maximum value gives the judgement. In the above case, occurrence of slip is detected at time Ps at which the apparent acceleration exceeds the theoretical maximum value, and termination of the slip is detected at time T2 at which the acceleration becomes negative.

Detailed Description Text (184):
At step (b-305), the control unit judges whether or not the vehicle requires a slip control. More precisely, the apparent acceleration (A) is compared with a maximum or threshold value (A1), and if A is equal to or larger, than (A1) it is judged that the slip control is needed. Otherwise, it is judged that the slip control is not needed. The control proceeds to step (b-306) in the former case and proceeds to step (b-308) in the latter case.

Detailed Description Text (185):
At step (b-306), the control unit sets a control flag positive and determines a control time interval Ts based on various variables such as the duration of the slip, the speed of the vehicle before slip, etc. The control flag is used to judge whether or not the control is in the slip control and Ts is used to indicate whether or not to get out of the slip control in the following procedures.

Detailed Description Text (186):
Succeeding to step (b-306), the control unit send a signal to the transmission ratio varying mechanism to hold the transmission ratio as it was before slip, and proceeds to step (a-1) in step (b-307). Thus the transmission ratio is protected from being altered to a lower ratio due to an increase of the engine speed.

Detailed Description Text (187):
At step (b-308), the control unit examines whether or not the control flag is on. If the flag is off, the control jumps out of the slip control. If the flag is on, the control unit judges whether or not the situation wherein the acceleration is negative continues longer than the prescribed time interval Ts. If the duration is not longer than Ts, the control proceeds to step (b-307) to further continue the slip control. Otherwise, the control unit judges that the situation gets out of the slip control, sets the operation flag negative and returns to step (a-1).

Detailed Description Text (188):
According to the above-mentioned control procedure, slip of the driving wheel while the driving force is transmitted to the driving wheel, which is called acceleration slip hereinafter, is detected by the control unit and the transmission ratio is kept unchanged so as to avoid further slip of the driving wheel. The control unit judges that the acceleration slip continues while the apparent acceleration calculated from a rotational speed of the driving wheel is positive and keeps the transmission ratio at the initial ratio. When the apparent acceleration becomes negative, the control gets out of the slip control.

Detailed Description Text (189):
In a further modified slip control, the control unit store the apparent speed of the vehicle when it exceeds the maximum possible speed (initial speed) judging naturally that the driving wheel starts spinning. Then, the control unit judges that the driving wheel has recovered a grip of the ground when the apparent speed becomes equal to the initial speed again.

Detailed Description Text (206):
If the clutch is set off while jumping, what is important is that the driving wheel recovers a driving grip of the ground as soon as it comes in contact with ground again, which is an object of the jump control. Because the jump control and the lock-slip control are performed prior to the inertial running control, the transmission ratio is adjusted properly even if the clutch is set off while jumping or lock-slipping according to the former controls.

Detailed Description Text (256):
While the driving wheel is spinning, due to an excessive driving force, as the vehicle is being accelerated, the transmission ratio is kept constant in order to secure a quick recovery of a grip of the ground. When the driving wheel is locked due to an excessive braking force while the vehicle is slowing down, the transmission ratio is set at a high ratio in order to assure a quick acceleration after the slip.

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| L4 | L3 and slip and traction | 239 | L4 |
| L3 | L2 and L1 | 1301 | L3 |
| L2 | transmission near3 (rpm or revolution or speed or velocity) | 32466 | L2 |
| L1 | (wheel or tire) near (speed or velocity) | 12422 | L1 |

END OF SEARCH HISTORY